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RHUS VERNICIFLUA AND JAPANESE DAMASCENE WARE

OAKES AMES

Plate 27

IN CHINA AND JAPAN where the resin of *Rhus verniciflua* is used in the manufacture of lacquer ware, *Rhus dermatitis* or lacquer poisoning, is recognized as an industrial disease. Usually this disease is confined to workmen who gather the fresh resin or apply it, but from time to time, not only in China and Japan, but in countries to which lacquer ware is exported, well marked cases of *Rhus* poisoning occur among people who handle lacquered articles.

In April 1930 a rather extraordinary outbreak of lacquer poisoning occurred among passengers returning from Japan to the United States on the S. S. Columbus of the North German Lloyd Line. One woman experienced a severe case of poisoning after wearing a necklace of Japanese damascene ware purchased in Kyoto. Her neck, where the necklace had rested, was encircled by the papular eruptions characteristic of *Rhus dermatitis*. It was supposed that the necklace had been purchased from a salesman whose hands had been in contact with fresh lacquer, but this supposition was rendered doubtful when other women on the steamer exhibited well marked cases of *Rhus dermatitis* as a result of wearing necklaces and bracelets of damascened metal purchased in Japan.

Japanese damascene ware resembles very closely the product of Damascus from which it takes its name, and appears to be wholly composed of metal, that is, of gold or silver inlaid on oxidized steel. Assuming that the Japanese product is wholly metallic, it is difficult to understand how the symptoms of poisoning were stimulated that occurred among the passengers of the S. S. Columbus. There would be nothing to fear from any polishing substance or protective coating necessitated by the classic methods of manufacture.

Investigations indicated that the damascened articles,—such as necklaces, bracelets, cuff-links, cigarette cases and boxes,—purchased in Japan by the passengers on the S. S. Columbus, differed

materially from genuine damascene, not only in the methods of manufacture, but in composition. The black background employed to bring out the delicate designs executed in gold and silver, proved in every case to be non-metallic and to consist of a resinous substance which yielded readily to a cutting instrument.

The common type of modern Japanese damascene ware that one finds in the shops to-day, is made by incising numerous lines on a polished surface of steel and pounding in a design of gold or silver or both, in low relief. Then black lacquer, prepared from the resin of *Rhus verniciflua* is applied and brought up level with the surface of the design. Unless actually disturbed with cutting instruments the lacquer is extraordinarily durable and will withstand drastic solvents without being materially damaged. Even when boiled for a short time with such solvents as carbon tetrachloride, toluene and butyl acetate, specimens of Japanese damascene that are in part composed of lacquer exhibit only slight injury. Indeed, lacquer made from *Rhus verniciflua* is one of the few materials of botanical origin that will come through the ordeal of this treatment and retain its original aspect. It is well known that Japanese lacquer resists the solvent effects of alcohol and is often used in the manufacture of cocktail cups.

Technically the term damascene should be confined to articles made of iron or steel inlaid with more precious metals. Tourists who purchase the supposedly damascened articles carry away the impression that only metals are used. It is true that some of the manufacturers of Japanese damascene admit that lacquer constitutes a part of the design. One of the large manufacturers in Kyoto describes the process as follows: "Lines are cut double hatchway on a polished surface of steel, and gold and silver are pounded down, a design being worked out in this way. Either lacquering or oxidizing process is given next, which is followed by the finishing work of polishing or engraving." The use of lacquer to imitate oxidized steel, while permissible as a form of artistic expression, is indefensible if deception is being practiced and the substitution of black lacquer for oxidized steel is made with fraudulent intentions. There must be a considerable difference in the cost of manufacture between lacquer-damascene and damascene of the original type, and it is evident that the profit is great when what may be termed lacquer-damascene is sold for the same price that would have to be established for true damascene.

When lacquer is comparatively fresh it is still capable of causing the characteristic symptoms of *Rhus* poisoning and when dry may be toxic to people who are especially susceptible to the poisonous

effects of Poison Ivy (*Rhus toxicodendron*) and Poison Dogwood (*Rhus vernix*). If bracelets and necklaces are worn for prolonged periods, symptoms of poisoning will begin to appear, redness of the skin being in evidence in susceptible people, in about two days. Undoubtedly the season of the year will have a direct influence on the degree of toxicity, and if in hot weather lacquer-damascene of comparatively recent origin is worn against the skin by one who is extraordinarily sensitive to *Rhus* poisoning, well marked symptoms of dermatitis may develop rapidly and cause serious trouble. The necklace which caused the most severe case of *Rhus* dermatitis on the S. S. Columbus (cf. Pl. 29) is in large part made of gold, the lacquered parts being of comparatively negligible area. Furthermore only the metallic part of the necklace was worn in direct contact with the skin, yet the symptoms of poisoning encircled the neck of the wearer.

SUMMARY

The cases of *Rhus* dermatitis or lacquer poisoning caused by wearing or handling Japanese damascene are attributable to lacquer, the prepared latex of *Rhus verniciflua* Stokes, dyed black. The Japanese product in which lacquer is used should be called lacquer-damascene to avoid confusion and to warn those who are susceptible to *Rhus* or lacquer poisoning.

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EXPLANATION OF PLATE 27

The bracelet at the top of the plate has one of the designs (executed on a metal tablet) removed to show the method of construction. (Bot. Mus. Harvard U. no. 4485.) The cigarette case is lacquered where black is shown. (Bot. Mus. Harvard U. no. 4486.) The necklace is reproduced from the one which caused the first case of *Rhus* dermatitis on the S. S. Columbus. (Bot. Mus. Harvard U. no. 4463.)

THE ORIGIN AND RELATIONSHIPS OF THE POMOIDEAE

KARL SAX

Plate 28

CYTOLOGICAL studies of the more polymorphic genera of the Rosaceae have shown the probable origin and relationship of many species. The larger genera such as *Rosa*, *Rubus*, and *Prunus* each contain a number of species with the same basic chromosome number, and a large series of polyploids. The Pomoideae on the other

hand consists of genera which are usually diploid, with a few tetraploids and triploids.

The basic chromosome number is 7 for the larger genera of the Rosoideae and 8 for the Prunoideae, but is 17 for all of the genera in the Pomoideae. Nebel (1929) and Darlington and Moffett (1930) have suggested that the Pomoideae are aneuploids derived from a 7 chromosome ancestor by chromosome duplication. Nebel suggests that the present *Malus* species are halved pentaploids derived from an ancestor with 35 somatic chromosomes. Darlington and Moffett also believe that the basic chromosome number of *Malus* is 7, but that the present forms are secondary polyploids with a basic number of 7 pairs of chromosomes, of which 4 are represented twice and 3 are represented three times. These authors go even further and suggest that the morphological characteristics of the Pomoideae are due to the establishment of a secondary basic chromosome number. These conclusions are based on the fact that the more important genera of the Rosoideae have 7 chromosomes as the basic number and that in species of *Malus* quadrivalents and sexivalents are found at the first meiotic divisions. Such an unbalanced secondary number of chromosomes must be considered remarkable in view of the fact that all of the species and varieties in the Pomoideae are orthoploid, with chromosome numbers of 17 or multiples of 17.

The present investigation was made in order to obtain chromosome counts of most of the genera of the Pomoideae. In view of the theory that this sub-family originated from a 7 chromosome form, a further survey of chromosome numbers was made in other genera of the Rosaceae. Most of the chromosome counts were obtained from acetocarmine smears of pollen mother cells. Mr. Dermen has made the counts of the *Prunus* species and most of the Spiraeoideae recorded, while Mrs. Sax is responsible for the counts in the *Amelanchier* species. The taxonomic grouping is based on Rehder's Manual (1926).

The chromosome numbers of representative genera are given in the following table. Counts obtained by previous investigators are indicated. In genera with polyploid species only the basic and highest polyploid numbers are given.

CHROMOSOME NUMBERS IN THE ROSACEAE

Sub-family	Genus	Chromosome No.	Native habitat
Spiraeoideae	<i>Physocarpus</i>	9	N. Am., Asia
	<i>Spiraea</i>	8 +	N. Am., Asia
	<i>Pentactina</i>	9	Korea
	<i>Sibiraea</i>	9	Eu., Asia
	<i>Exochorda</i>	8	Asia

Pomoideae	<i>Cotoneaster</i>	17-34	Eu., Afr., Asia
	<i>Mespilus</i>	17	Eu.
	<i>Crataegus</i>	16-32 L. ¹	
		17-34	N. Am., Eu., Asia
	<i>Sorbus</i>	17	N. Am., Eu., Asia
	<i>Aronia</i>	17	N. Am.
	<i>Photinia</i>	17	Asia
	<i>Eriobotrya</i>	17 M.	Asia
	<i>Chaenomeles</i>	17 K. M.	Asia
	<i>Cydonia</i>	17 R. K.	Asia
	<i>Malus</i>	17-34 ² R. K. N. D.	N. Am., Eu., Asia
	<i>Pyrus</i>	17- ² R. K.	Eu., Asia
	<i>Amelanchier</i>	17-34	N. Am., Eu., Asia
Rosoideae	<i>Neviusia</i>	8	N. Am.
	<i>Rhodotypus</i>	8	Asia
	<i>Rubus</i>	7-28 L. C.	N. Hemisphere
	<i>Potentilla</i>	7-14 Ti. S.	N. Hemisphere
	<i>Rosa</i>	7-28 T. B. H. E.	N. Hemisphere
Prunoideae	<i>Fragaria</i>	7-28 L. I.	Am., Eu.
	<i>Maddenia</i>	16	Asia
	<i>Prunus</i>	8-88 ² K. O. D. Me.	N. Hemisphere
	<i>Prinsepia</i>	16	Asia
	<i>Osmaronia</i>	6 K.	N. Am.

¹ L.—Longley, M.—Morinaga, K.—Kobel, R.—Rybin, N.—Nebel, D.—Darlington, T.—Tackholm, B.—Blackburn and Harrison, H.—Hurst, E.—Erlanson, I.—Ichijima, Me.—Meurman, C.—Crane, Ti.—Tischler, S.—Shimotomai.

² Triploids also found especially among the cultivated varieties of *Malus* and *Pyrus*.

The chromosome counts in the Spiraeoideae were obtained from the following species:—*Physocarpus monogynus*, *P. intermedius*, *P. stellatus*, and *P. capitatus*; *Spiraea pubescens* and the hybrid *S. oxyodon*; *Pentactina rupicola*; *Sibiraea laevigata*; and *Exochorda Giralddii Wilsonii*.

Most of these genera contain few species and *Pentactina* is monotypic. There are about 80 species of *Spiraea*, however, and a considerable number of species hybrids. This genus undoubtedly contains some polyploid species although exact counts of the higher chromosome numbers could not be obtained. The basic numbers for this sub-family are 8 and 9.

In the Rosoideae chromosome counts were obtained for the following species:—*Neviusia alabamensis*, *Rhodotypus scandens*, *Potentilla fruticosa* (7) and *P. tridentata* (14). *Neviusia* and *Rhodotypus* are monotypic genera. *Potentilla* is a large genus with more than 300 species of which only a few are woody. Both the woody and herbaceous species of *Potentilla* have 7 pairs of chromosomes as the basic number (Tischler 1929, Shimotomai 1929) instead of 8 as earlier investigators reported. The haploid chromosome number is 8 for the two monotypic genera, but is 7 for the polymorphic and polyploid genera *Rubus*, *Rosa*, *Potentilla* and *Fragaria*.

In the subfamily Prunoideae, chromosome counts have been obtained for *Maddenia hypoxantha*, and *Prinsepia uniflora*. According to Kobel the monotypic genus *Osmaronia* has only six pairs of chromosomes. The large genus *Prunus* has eight chromosomes as the basic number. Chromosome counts of the following species have also been made. Species with eight pairs of chromosomes include *Prunus incana*, *P. avium*, *P. serrulata sachalinensis*, *P. incisa serrata*, *P. subhirtella*, *P. glandulosa*, *P. pennsylvanica*, *P. allegheniensis*, *P. pumila susquehanae*, *P. angustifolia*, *P. americana*, *P. japonica Nakaii*, *P. orthosepala*, *P. hortulana*, *P. Munsoniana*, *P. maritima*, and *P. lanata*. Two species were found to be tetraploids; *Prunus Padus* and *P. virginiana*. Previous investigators have found diploids, triploids, tetraploids, hexaploids and aneuploids in the genus *Prunus* (Kobel 1927, Okabe 1928, Darlington 1928-30) and in one species Meurman (1929) found about 88 pairs of chromosomes. The two genera *Maddenia* and *Prinsepia* are apparently tetraploids but *Osmaronia* does not seem to have the typical basic number of 8.

CHROMOSOME NUMBERS IN THE POMOIDEAE

All of the genera of the Pomoideae have 17 pairs of chromosomes or polyploids with a basic number of 17. In some genera, especially *Cotoneaster* and *Crataegus*, it was difficult to obtain clear division figures with the acetocarmine technique. In some cases there appeared to be only 16 pairs of chromosomes in *Crataegus* as Longley (1924) has reported. In most genera there is more or less association between the chromosomes at the first meiotic division, as previous investigators have found, so that it is often difficult to determine the exact number of bivalent chromosomes. The following chromosome counts were determined from acetocarmine smears of pollen mother cells.

Cotoneaster moupinensis and *C. salicifolia* are diploids with 17 pairs of chromosomes while *C. horizontalis* is a tetraploid. The 17 bivalent chromosomes of *C. moupinensis* at diakinesis are shown in figure 4. The chromosomes of the tetraploid species are shown in figure 3. Other species were also found to have more than 17 pairs of chromosomes although exact counts were not obtained. It seems probable that a relatively large proportion of the *Cotoneaster* species are polyploids.

Mespilus germanica has 17 pairs of chromosomes and not 16 pairs as reported by Meyer (1915). The meiotic chromosomes at 1 M are shown in figure 2.

Only a few species of *Crataegus* were examined because this genus was thoroughly studied by Longley (1924). Longley reports that 16 is the basic chromosome number in *Crataegus* and he finds numerous triploid and a few tetraploid species. The great variation in morphological characters in this genus is attributed to hybridization between species.

In several species of *Crataegus* the acetocarmine preparation showed only 16 pairs of chromosomes but other species undoubtedly have 17 chromosomes as the basic number. The 16 groups of chromosomes in the hybrid *C. Lavalleyi* are shown in figure 1. In *C. Deweyana* there are clearly 17 pairs of chromosomes at late diakinesis (figure 8). In this species, as well as most other species in the Pomoideae, there is a tendency for bivalents to be associated in groups of two or even three. At the first metaphase *C. lawrencensis* appears to have 17 or 18 pairs of chromosomes (figure 7), but at the telophase of the division there are about 33 chromosomes at one pole (figure 6) and 32 at the other, with one lagging chromosome still at the metaphase plate. The chromosomes in this pollen mother cell were especially clear. It is possible that *Crataegus* is a transitional genus with both 16 and 17 chromosome forms, and that such species as *C. lawrencensis* with apparently 32 bivalents and 2 univalents could produce segregates with either 16 or 17 chromosomes as the basic number. The association of chromosomes into tetravalents is the result of duplication of the primary basic number of chromosomes.

In the *Sorbus* species there is much less tendency for the bivalents to form a secondary association and exact chromosome counts were easily made. *Sorbus Aucuparia*, *S. americana*, *S. discolor*, *S. alnifolia*, and *S. Aria* are all diploids with 17 pairs of chromosomes. The meiotic chromosomes of *S. aucuparia* and *S. alnifolia* are shown in figures 5 and 12.

The closely related genus *Aronia* also has 17 pairs of chromosomes. Two of the three species were studied and both *A. melanocarpa* and *A. arbutifolia* were found to be diploids (figure 11).

Only one species of *Photinia* was available for study in the Arnold Arboretum. It was found to be diploid with 17 pairs of chromosomes which are shown in figure 10.

The chromosome number of *Eriobotrya* was determined from root tip counts from seedlings grown in the greenhouse. The somatic chromosome number is 34 which is in accord with the count obtained by Morinaga (1929) for the same species, *E. japonica*.

The 17 chromosomes of *Chaenomeles sinensis* are shown in figure 9. This count agrees with the number previously reported by Mor-

inaga (1929). Rybin (1926) and Kobel (1927) also find 17 pairs of chromosomes in the closely related genus *Cydonia*.

Rybin (1926) found 34 somatic chromosomes in several species of *Pyrus* and Kobel (1927) found 17 bivalents in certain species and varieties, but a variable number of chromosomes in many of the cultivated forms. It is probable that these forms with irregular chromosome behavior are triploids with 51 somatic chromosomes.

The genus *Malus* has been investigated by a number of cytologists (Rybin 1926, Kobel 1927, Nebel 1929, and Darlington and Moffett 1930). Most of the species are diploids with 17 pairs of chromosomes, but several tetraploid species have also been described. In two cases triploids were found but other forms of the same species were found to be diploid. Triploid species could not reproduce themselves by sexual reproduction and would be expected to occur only occasionally. Among the cultivated varieties of apples, however, triploid forms are frequently found, and although they are partially sterile, enough flowers develop to produce a commercial crop of fruit. About 75 horticultural varieties of apples have been investigated and of these about one-third are triploids. No tetraploid horticultural varieties have been described.

Counts of somatic chromosomes were obtained from root tips of seedlings several years ago, but since so many species have been studied recently, it was considered unnecessary to carry this phase of the work further. The following species were found to be diploid: *Malus baccata*, *M. prunifolia*, *M. micromalus*, and *M. brevipes*. *Malus angustifolia*, *M. coronaria*, and *M. glaucescens* are tetraploids. In general these results are in accord with those of previous investigators. *Malus adstringens*, *M. Scheideckeri*, *M. Soulardi*, *M. robusta*, *M. zumi*, and *M. Dawsoniana*, are all recognized as species hybrids by Rehder (1926) and all of them are diploids and have 34 somatic chromosomes. It is possible, of course, that chromosome counts from seedlings do not indicate the chromosome number of a parental tree because a triploid might produce a diploid seedling, but the fertility of the parental trees and the uniformity in chromosome counts in the seedlings indicated that the counts obtained from seedlings also represent the parental chromosome numbers in these species.

All of the pure species of *Amelanchier* which have been studied are diploids, but two natural species hybrids are tetraploids. The diploid species are *Amelanchier asiatica*, *A. humilis*, *A. stolonifera*, *A. sanguinea* and *A. oblongifolia*. The chromosomes of *A. oblongifolia* are shown in figure 16. In *Amelanchier*, as in *Sorbus*, there is little tendency for the bivalents to form secondary associations.

The tetraploid hybrid *A. grandiflora* is a cross between *A. canadensis* and *laevis*, while *A. spicata* is a cross between *A. oblongifolia* and *stolonifera* (?) according to Rehder. In these tetraploids the chromosomes usually pair as bivalents at meiosis.

GENERIC HYBRIDS IN THE POMOIDEAE

A relatively large number of natural generic hybrids have been found in the Pomoideae. Among the hybrids recognized by Rehder are *Crataegomespilus* (*Crataegus* \times *Mespilus*), *Sorbaronia* (*Sorbus* \times *Aronia*), *Sorbopyrus* (*Pyrus* \times *Sorbus*), *Amelasorbus* (*Amelanchier* \times *Sorbus*), and *Pyronia* (*Pyrus* \times *Cydonia*).

Representatives of three of these generic hybrids are growing in the Arnold Arboretum and the chromosome behavior of two of the hybrids has already been described (Sax 1927).

Two types of *Crataegomespilus* have been studied. *Crataegomespilus Dardari* is a graft hybrid which developed from the graft union of *Mespilus germanica* on *Crataegus monogyna*. Meyer's (1915) study of this graft hybrid shows that the outer layers of tissue are those of *Mespilus* although the fruit shape is like that of *Crataegus*. It is probable that the gametes are derived from *Mespilus* tissue. The number of chromosomes at the first reduction division is 17 as shown in figure 15 and are probably from *Mespilus* cells.

The generic hybrid *Crataegomespilus grandiflora* is supposed to be a cross between *Crataegus Oxyacantha* and *Mespilus germanica*. *Mespilus germanica* is a diploid species and according to Longley *C. Oxyacantha* is also a diploid form, but the F_1 hybrid seems to have more than 17 pairs of chromosomes. There are 17 groups of chromosomes at the first metaphase shown in figure 14, but at late diakinesis (figure 13) there are about 17 bivalents and 6 univalents. It is possible that there are only 34 somatic chromosomes in this hybrid and that there is incomplete pairing of chromosomes, but the presence of so many apparently bivalent chromosomes makes it seem more probable that one of the parental gametes was diploid. About 75 per cent of the pollen is obviously sterile.

Sorbaronia Dippelii is a cross between *Sorbus Aria* and *Aronia melanocarpa*. Both of these parental species are diploids. In the F_1 hybrid there is apparently complete compatibility of the two sets of chromosomes and 17 chromosomes are found at the first meiotic division of the pollen mother cells (figure 21). Several other generic hybrids between *Sorbus* and *Aronia* are also described by Rehder (1926). Prof. J. G. Jack has found several such hybrids and Mr. F. Hyland has recently found a hybrid between *S. Aucuparia*

and *A. floribunda* growing near Orono, Maine. These hybrids all seem to be completely fertile and set fruit abundantly.

A hybrid between *Sorbus* and *Pyrus* is known as *Sorbopyrus auricularis* and is supposed to be a cross between *P. communis* and *S. Aria*. The variety *bulbiformis* is a seedling of *S. auricularis* and is more like *Pyrus* than the F_1 hybrid. A cytological examination of the pollen mother cells of this variety shows that there are 34 chromosomes at metaphase of which about half are univalents (figure 18). The first meiotic division is somewhat irregular but usually the bivalents seem to pass to the poles first and most of the univalents lag behind. A typical division figure is shown in figures 17-19 where there are 17 chromosomes at one pole, 19 at the other and about 14 lagging univalents.

The variety *bulbiformis* evidently has two sets of *Pyrus* chromosomes and one set of *Sorbus* chromosomes, and probably originated by the union of a diploid F_1 egg cell with a haploid *Pyrus* male gamete. The fact that the chromosomes in the triploid segregate, and do not form trivalent chromosomes does not necessarily mean that the *Pyrus* and *Sorbus* chromosomes are incompatible, but since the F_1 hybrid is relatively sterile this interpretation is probably correct. The parental genera must be closely related, however, since the two sets of chromosomes function normally in somatic development.

Pyronia Veitchii is a hybrid between *Cydonia oblonga* and *Pyrus communis*. The F_1 plant sets fruit but no seeds are formed. Apparently these genera are closely related but pairing between the two sets of chromosomes does not occur.

Another generic hybrid discovered by Prof. Jack is *Amelasorbus Jackii*, which is a cross between *Amelanchier florida* and *Sorbus sitchensis*. Plants of this hybrid in the Arboretum are not large enough to produce flowers so that nothing is known about its cytological behavior. It sets seed freely in its native habitat which would indicate that the two parental sets of chromosomes are compatible with each other, although it is possible that it is a tetraploid, as are the *Amelanchier* species hybrids. If so, the F_1 might be fertile even if the parental chromosomes did not pair with each other.

SPECIES FORMATION IN THE ROSACEAE

Cytological and genetic studies in several genera of the Rosaceae have shown the relationship and origin of many species. A brief survey of this work will be presented here as a basis for the discussion of the origin and relationships of the genera of the Pomoideae.

The polymorphic genus *Rosa* has been found to contain an extensive series of polyploid types with diploid, triploid, tetraploid, pentaploid, hexaploid, and octoploid forms. (Tackholm 1922, Blackburn and Harrison 1921, Hurst 1927 and Erlanson 1929.) More than 1000 species and forms of *Rosa* have been examined and these include all of the sections of the genus distributed over the northern hemisphere. Of these forms studied 377 are diploids with 7 pairs of chromosomes, while over 600 are polyploids. A few aneuploid forms have been found by Tackholm and Erlanson, but practically all of the species have a chromosome number of 7 or a multiple of 7.

According to Hurst there are five fundamental diploid types, each with a different set of 7 chromosomes. These five fundamental diploid sets of chromosomes have been identified by genetic and cytological tests. The chromosomes of one set will not pair with those of another set, and each set is responsible for certain morphological differences. The species containing set AA is represented by *R. sempervirens*, BB by *R. sericea*, CC by *R. rugosa*, DD by *R. carolina* and EE by *R. macrophylla*. A duplication of the same set of chromosomes results in what Hurst calls duplicational polyploid varieties which have the same characteristics as their basic species. Differential polyploids, however, contain two or more different sets of chromosomes, such as AABB, and are distinct species. Twenty-six regular polyploid species are possible of which 18 have been identified. Irregular polyploids are those containing at least one set of bivalent chromosomes and from one to four sets of univalents. Of the 180 different possible combinations which would result in irregular polyploid species, only 25 have been identified in the wild state. According to Hurst there are 211 possible species of *Rosa*, if the 180 irregular polyploids are included, of which about 50 have been identified. Some taxonomists have recognized nearly 5000 species of *Rosa* although Rehder states that there are only one to two hundred good species.

The irregular polyploids are best represented by the species of the Caninae section. These species have 7 bivalents and either 14, 21 or, in a few species, 28 univalents. Tackholm found that the reduction was irregular in these forms. The bivalents divide normally but the univalents lag behind and are irregularly distributed in the first and second meiotic divisions of the pollen mother cells. Micronuclei are often formed, pollen sterility is high, and the few functional pollen grains have 7 chromosomes derived from the division of the bivalents. In the reduction division of the megaspore mother cells, however, 7 chromosomes from the bivalents

and all of the univalents pass to one pole. From this cell the female gamete is formed with 21, 28 or 35 chromosomes. It may be fertilized with a 7 chromosome male gamete and reproduce the parental type, or due to apomictical reproduction the parental type is reproduced asexually. Thus these types of unbalanced polyploids of undoubted hybrid origin breed true due to the peculiar chromosome distribution and apomixis.

The cytological and genetic work on *Rosa* clearly indicates that most of the numerous species and forms of the genus have originated from a few basic types by hybridity and polyploidy or by hybridity followed by apomixis.

The genus *Rubus* also contains a series of polyploid forms. Longley (1924) has found diploid, triploid, tetraploid, pentaploid, hexaploid, and octoploid species in this genus. Crane and Darlington (1927) have presented cytological and genetic evidence which seems to show that there are at least three different basic sets of 7 chromosomes each, in this genus. The genetic evidence seems to show that the chromosomes of two different basic septets may also pair with each other (Crane and Darlington). Apparently in this genus chromosome differentiation is not complete so that pairing occurs between different sets of chromosomes. According to Crane and Darlington unreduced egg cells frequently function in *Rubus* hybrids and apogamy also occurs. According to Longley there are about 10 bivalents at the first meiotic division of triploids and about 17 in pentaploids which would indicate that there is pairing between non-homologous chromosomes.

Fragaria is another polyploid genus containing diploid, tetraploid, hexaploid and octoploid species (Longley 1926, Ichijima 1926). The tetraploid form has not been found in natural species, but was obtained from a cross between two 7 chromosome species followed by somatic doubling in F_1 (Ichijima). Ichijima found that *Duchesnea indica* has 42 gametic chromosomes and since it can be crossed with *Fragaria* it is possibly a dodecaploid form of *Fragaria*.

The chromosomes of all 7 chromosome species seem to be compatible and pair in species hybrids. In crosses between 7×28 chromosome species there are 7 bivalent and about 21 univalents at meiosis in the F_1 which would indicate that there are at least three and possibly four different sets of 7 chromosomes each (Ichijima 1926).

Yarnell (1929) found that Ichijima's tetraploid bred true. When back crossed with one of the 7 chromosome parents a triploid was produced. In this triploid 7 bivalents and 7 univalents were occasionally found at the first meiotic division of the pollen mother

cells but usually there were 10 bivalents and 1 univalent. At the second reduction division 10 or 11 chromosomes were most frequent at metaphase. The triploid plants were partially fertile. In *Fragaria*, as in *Rubus*, there is evidently pairing of the non-homologous chromosomes.

The genus *Prunus* contains diploid, triploid, tetraploid, hexaploid and aneuploid species (Kobel 1927, Okabe 1928, Darlington 1928, 1930), and in one species Meurman (1929) has found a remarkable case of polyploidy where the basic somatic chromosome number is reduplicated eleven times. The basic somatic chromosome number is 8, and many species, even those belonging to different subgenera, seem to have similar sets of chromosomes so that chromosome pairing occurs in many species hybrids. Darlington (1930) finds chromosome pairing in a series of hybrids: *P. domestica* (6n) \times *P. cerasifera* (2n), *P. triflora* (2n) \times *P. cerasifera* (2n), *P. triflora* (2n) \times *P. Persica* (2n) and *P. Persica* (2n) \times *P. Amygdalus* (2n). *Prunus Persica* (Peach) and *P. Amygdalus* (Almond) belong to the subgenus *Amygdalus* while the species of Plums belong to the subgenus *Prunophora*. In the cross between *P. domestica* and *P. cerasifera* the F_1 behaves like a tetraploid which indicates that there are at least two similar sets of chromosomes in the hexaploid parent. In the cross between the Peach and the Almond some chromosomes frequently fail to pair, but fruit production is not seriously impaired. Rehder (1926) also describes a number of hybrids between species of different subgenera. The hybrid *P. dasycarpa* is probably a cross between *P. Armeniaca* (Apricot) and *P. cerasifera* (Plum) and rarely sets fruit. Only in one case is there any record of a cross between cherry and plum species. *Prunus pumila* (Sand Cherry) \times *P. cerasifera* (Plum) produced a hybrid which sets fruit. In general the first two subgenera of this genus seem to be genetically similar in many cases, although it is improbable that all crosses between species of these two groups would produce fertile hybrids. Subgenera 4 and 5, *Padus* and *Laurocerasus*, are somewhat similar, but are probably well differentiated from the other groups. Thus in the genus *Prunus* there are at least several different basic sets of chromosomes and in addition there is some evidence that chromosome differentiation is now in progress.

Okabe finds that the flowering Cherries are triploids which accounts for their sterility. The Sweet Cherries (*P. avium*) are usually aneuploid with from 17 to 19 somatic chromosomes (Darlington 1928). The occurrence of autosyndesis and secondary chromosome association in hybrids and species of *Prunus* indicate

that polyploidy in this genus is often due to duplication of a single basic set of chromosomes. Species differentiation seems to be due largely to differences in basic sets of chromosomes.

The larger genera of Rosaceae have many similar characteristics in chromosome behavior. They all contain a series of polyploid species which may be caused by a duplication of the same basic set of chromosomes, or may be due to the combination of different basic sets of chromosomes. Most of the species are orthoploid and aneuploid forms are rarely found in nature. Species formation is due to genetic differentiation of basic sets of chromosomes so that the chromosomes often fail to pair in species hybrids, and to hybridization of distinct species followed by polyploidy. The production of diploid gametes is relatively frequent in this family and apogamy often permits the reproduction of unbalanced polyploid types which could not be maintained by sexual reproduction.

The chromosomes in autopolyploid species usually form bivalents instead of tetravalents at the first meiotic division due to the lack of sufficient chiasmata to bind more than two chromosomes together. In *Rubus*, *Fragaria* and *Crataegus* non-homologous chromosomes seem to pair in triploids although it seems improbable that there is an intimate association of chromatids in such an association of chromosomes. The association of non-homologous chromosomes does suggest, however, that chromosome pairing is not always a reliable indication of genetic homology.

THE ORIGIN AND RELATIONSHIPS OF THE GENERA OF POMOIDEAE

The genera of Pomoideae form a distinct and closely related group. All of the genera investigated have 17 pairs of chromosomes as the basic number. This subfamily is undoubtedly of Asiatic origin since all but three of the 18 genera enumerated by Rehder are represented by Asiatic species. The monotypic genus *Mespilus* is found in south-eastern Europe and Persia, while the monotypic genus *Peraphyllum* and the genus *Aronia* are natives of North America. *Mespilus*, however, is very closely related to *Crataegus*; *Aronia* is simply a form of *Sorbus* as indicated by genetic and cytological relationships; and *Peraphyllum* may be only an aberrant type of *Amelanchier*. Twelve of the genera of Pomoideae are not found in America while 7 are found only in Asia.

We may conclude then that the Pomoideae originated in Asia and that before the migration of the various species over the northern hemisphere, a period of perhaps millions of years, this group of plants had 17 chromosomes as the basic number. It would be most remarkable if each genus developed the same unbalanced polyploid number independently.

The chromosome behavior of any genus of this subfamily should, therefore, indicate the chromosome relationships of the entire group. According to Nebel the genus *Malus* is a halved pentaploid with 7 as the basic chromosome number. There is little evidence for this conclusion except that there is a tendency for the meiotic chromosomes to form secondary associations. Darlington and Moffett believe that *Malus* has developed from a 7 chromosome type, of which four chromosomes are represented twice and 3 chromosomes represented three times, or in other words, the present *Malus* species are of the gametic constitution of $2n + 3$.

The evidence presented by Darlington and Moffett to support this theory is very weak. Multiple association of chromosomes occurs at the first meiotic division so that in extreme cases four quadrivalents and three sexivalents are seen in polar views instead of 17 bivalents. This clumping of chromosomes, especially in sectioned material, may have little significance, however, and in side views of the metaphase of the first meiotic division no such general association of bivalents is shown. In the eight figures of "diploids" shown on page 136 (Darlington and Moffett 1930) there is usually only one quadrivalent shown in each figure and in only one case is there any indication of a sexivalent group of chromosomes. In triploid apple varieties these investigators find bivalents and trivalents most frequently but also a few quadrivalents, and only one group of 9 chromosomes. As Darlington has shown earlier, the larger multiple associations might not be expected to occur frequently because of limitations in chiasma formation.

The chromosome numbers in seedlings from triploids is also presented to support the theory that *Malus* is a secondary polyploid with 7 chromosomes as the basic number. The progeny from a triploid pollinated with a diploid should have from 34 to 51 somatic chromosomes. Darlington and Moffett find that in 13 seedlings the lowest somatic count is 38 and the highest 47. Three seedlings have 40 somatic chromosomes and four have 41. The authors conclude that since the greatest chromosome frequency is 41 there is a tendency for the chromosomes to form segregates with the secondary diploid number 34, plus the primary haploid number 7. But it could equally well be argued that the basic number is 8. However, a frequency distribution of this type based on only 13 individuals shows nothing except that gametes with intermediate chromosome number are functional, and is of no significance in determining the basic chromosome number.

The work of Crane and Lawrence (1930) shows that the progeny of triploid Apple varieties are usually weak, presumably due to

their aneuploid condition. If the basic chromosome number of *Malus* is 7 and the basic sets are not sufficiently differentiated to prevent occasional pairing, as Darlington and Moffett believe, then one might expect new polyploid forms with 41 or 48 chromosomes to function as well as triploids, but such types have never been found.

If secondary chromosome association in the Pomoideae indicates polyploidy, it would seem much more probable that 8 is the original basic number and that the present genera are tetraploids plus one bivalent, as Tischler (1929) has assumed. Such an association of chromosomes would account for the occasional quadrivalents and sexivalents observed by Darlington and Moffett. It would also account for the 16 and 24 bivalent types of *Crataegus* found by Longley, although the 24 chromosomes in triploids may be due to pairing of non-homologous chromosomes as occurs in *Rubus* and *Fragaria*. Species and varieties which have an additional pair of chromosome are found in many genera whereas diploids or tetraploids plus several bivalents are rare in natural species. For instance most of the genera of Ericaceae have a chromosome number of 12 or a multiple of 12 (Hagerup 1928) but several genera, including the polymorphic genus *Rhododendron*, have 13 chromosomes as the basic number. The fact that one genus has 6 haploid chromosomes and another 18 would suggest that 6 is the primary basic chromosome number for this family and that *Rhododendron* is really a tetraploid plus one bivalent. It would seem improbable, however, that *Rhododendron* has been differentiated from other genera of Ericaceae simply by tetraploidy plus a bivalent chromosome. Darlington and Moffett suggest, however, that the establishment of the secondary basic chromosome number as described in *Malus* may be responsible for the differentiation of the Pomoideae from the other Rosaceae. The chromosome numbers in other Rosaceae do not support this suggestion. The aneuploid types of *Fragaria*, *Rosa*, and *Prunus*, are all very similar to the orthoploid species.

Many of the genera of Pomoideae are closely related and the subfamily as a whole includes a distinct group of genera. The fact that intergeneric hybrids can be made between *Pyrus* and *Sorbus*, *Cydonia* and *Pyrus*, *Amelanchier* and *Sorbus*, and between *Aronia* and *Sorbus* indicates that these genera are closely related. In fact *Aronia* must be considered simply as a form of *Sorbus* since crosses between these two genera produce fertile hybrids in which there is complete compatibility between parental chromosomes. It is possible that such genera as *Aronia* and *Mespilus* are now in the process of differentiation and that ultimately they might become genetically

distinct from their closely related forms so that chromosome pairing could not occur in intergeneric hybrids.

Many of the genera have never been crossed with each other although in many cases there has been ample opportunity for such hybrids to occur. There are no known hybrids between *Malus* and *Pyrus* although these genera are morphologically very similar.

In the larger genera of Pomoideae there are a few triploid or tetraploid species. In *Malus* there is good evidence that triploids and tetraploids are autopolyploids. The fact that about a third of the cultivated Apples are triploids and that no tetraploid varieties have been found indicates that chromosome duplication is caused by the occasional production of a diploid gamete. Similar evidence of autopolyploidy is also found in *Crataegus* and *Pyrus*. In *Amelanchier* the only known tetraploids are natural species hybrids, but it seems improbable that there are two different basic sets of chromosomes in these closely related parental species.

Polyploidy seems to have played a minor part in genus and species differentiation in the Pomoideae, although it is possible that the present diploid forms are polyploids with a basic chromosome number of 8. The genetic similarity of so many genera, and the morphological similarity of genetically differentiated genera, would indicate, however, that not more than one basic set of chromosomes was involved in the origin of the present genera. It seems probable that the genera of *Pomoideae* all originated by genetic changes in the basic set of 17 chromosomes and that various degrees of chromosome differentiation now exist in the different genera.

Within the genera further changes have occurred, but in many or perhaps in most cases they are not great enough to prevent chromosome pairing in species hybrids. The species of *Malus*, *Crataegus*, *Sorbus*, and *Amelanchier* hybridize rather freely in nature and many more species hybrids could undoubtedly be made. It is probable, however, that certain species in the larger genera are completely differentiated from each other. With the exception of *Crataegus* most of the genera of Pomoideae contain relatively few species.

According to Sargent (1922) there are more than 1000 species of *Crataegus*. In most cases species differentiation is based on minor morphological differences. Palmer (1925) in his introduction to the "Synopsis of North American *Crataegi*" states that "in these tables the color of the anthers, number of stamens, glabrous or pubescent character of corymbs at flowering time and general shape of the leaves were adopted for most groups, in the order named.
. . . . The taxonomic value of characters varies in different

groups, but generally there appears to be considerable variability even within the species in such particulars as the size of the flowers, the number in the corymbs and the compactness or laxity of the latter. The shape of the leaves is even less stable and dependable, many types often being found on a single branch. . . . The fruit is often one of the best guides to group distinctions, but there is quite too much variation in such particulars as shape, size and color for them to be depended upon rigidly as specific criteria. . . . Even the presence or absence of pubescence on the corymbs, often one of the best specific distinctions, cannot always be relied upon." The number of stamens and color of anthers are considered one of the most definite criteria for distinguishing species, but stamen number is also variable and anther color is often correlated with the color of the fruit.

Seedlings of the more ornamental types have been grown in considerable numbers at Rochester Park and at the Arnold Arboretum. My colleague, Mr. E. J. Palmer, informs me that in most cases the species of *Crataegus* breed true from seed, even to the most minute characters. Many species have a wide geographic range while others are of very local geographic distribution.

Longley has investigated about 80 species of *Crataegus* and found that about three-fourths of these species are triploids. Standish (1916) found that pollen sterility was prevalent in about 80 per cent of the species studied and in many cases pollen sterility was complete. It seems probable then that about 75 per cent of the *Crataegi* are triploids and form partially or completely sterile pollen. In view of the prevalence of triploids and pollen sterility in this genus it is remarkable that almost all species of *Crataegus* produce fruits abundantly. And still more remarkable some of these triploid forms with partially sterile pollen are known to breed true from seed. The only explanation of these phenomena seems to be that the triploid species are apogamous, or that seeds develop, from unreduced egg cells, so that the progeny receive the maternal set of somatic chromosomes and would of course breed true.

This explanation of seed production in the triploid *Crataegi* will account for the numerous species found in this genus. It is quite probable that there are at least several distinct types of *Crataegi* whose chromosomes are completely differentiated, but for the most part the different forms have similar basic sets of chromosomes. Variations caused by mutation and by hybridization between similar types which differed in such characters as size and color of fruit, pubescent or glabrous corymbs, color and number of anthers and leaf shape would produce many different types of segregates

differing only in these minor characters. The occasional production of diploid gametes, which seems to be characteristic of many genera of the Rosaceae, would frequently result in the production of triploids. These triploids seem to have developed a type of apogamous reproduction so that they breed true for both morphological characters and chromosome number. The older triploid types would be expected to have as great a geographic range as the diploids but the more recent ones would have only a local range.

Triploids could also be derived from homozygous diploids and from crosses between diploids and tetraploids. The production of triploid forms from diploid species will cause chromosome irregularity and pollen sterility, so that these phenomena are not necessarily associated with hybridity. Chromosome irregularity can also be caused by genetic factors, grafting, X-rays, segmental interchange between non-homologous chromosomes, and to some extent by environmental conditions.

There is also some evidence for apogamy in the genus *Malus* (Kobel 1927). Mr. W. H. Judd of the Arnold Arboretum tells me that some of the *Malus* species breed true from seed. In the Arboretum a number of species are grouped together and in many cases a species is represented by a single tree. In view of the fact that all horticultural varieties of *Malus* are cross pollinated, it is remarkable that any of the species grown in the Arboretum should breed true, unless they develop seed by apogamy or from unreduced egg cells. Certainly the cultivated varieties do not breed true from seed. In connection with some breeding experiments a number of flowers of *Malus theifera* were emasculated while the anthers were green and before the buds opened. The stigmas were also cut off at the same time and yet most of the fruits developed to maturity and seeds were obtained. Thus there are several lines of evidence that some species of *Malus* are apogamous or parthenogenetic, but further work should be done with both *Crataegus* and *Malus*.

In view of the close relationships of many genera of the Pomoideae and the frequency of fertile species hybrids in most genera the validity of the taxonomic grouping must be questioned. Of course the differentiation of species limits is a matter of personal opinion as best indicated perhaps by the recognition of about 5000 species of *Rosa* by some taxonomists as compared with 100 to 200 recognized by Rehder.

There should be a specific genetic test to determine species relationships. The use of the term species as used by most taxonomists seems to be almost as indefinite as it was in Darwin's time. From the standpoint of genetics and cytology a species might be defined as

a group of individuals of common descent which possess genetically similar sets of chromosomes. Such a definition will have to be modified at times in view of occasional genetic factors which may inhibit hybridization and affect the fertility of hybrids even in varietal crosses, but it is fundamentally sound. Of course such a test of genetics and cytological relationships can be applied only to a limited extent, but it should provide a more precise and natural system of classification for many groups of plants.

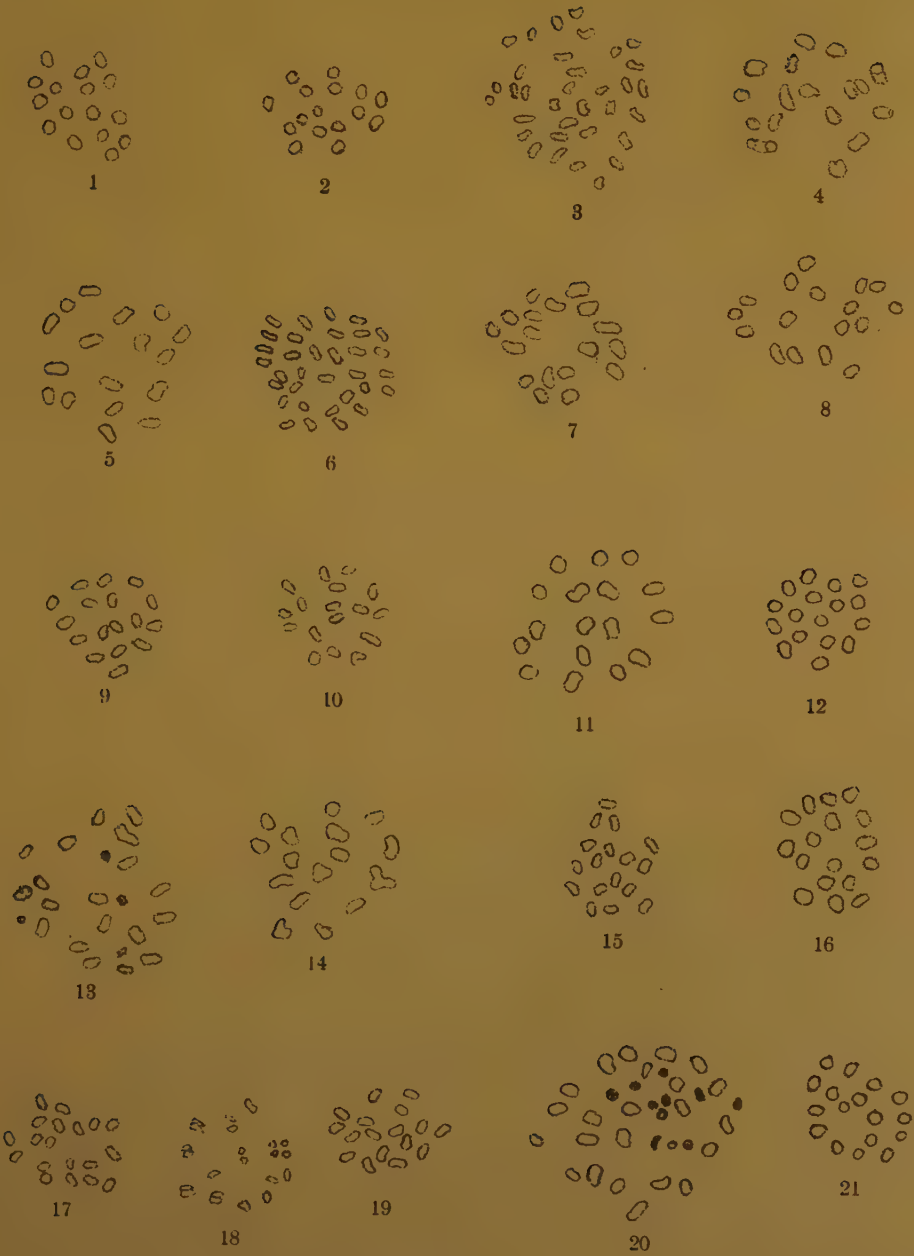
According to the genetic system of classification perhaps all of the Pomoideae could be classed as one genus and most of the present genera could be regarded as genetic species. In some cases two different genera, such as *Sorbus* and *Aronia*, should be combined in one genetic species. In the larger genera it is quite probable that there are a number of good genetic species so that the number of genetic species would exceed the present number of genera. This reversion to the older system of classification of the Pomoideae seems to be more in accord with genetic relationships than the present system, although a considerable amount of work must be done to determine the relationships of all of the genera and species.

SUMMARY.

In the Rosaceae the basic chromosome number is 8 and 9 for the Spiraeoideae, 7 and 8 for the Rosoideae, 8 for the Prunoideae, but is 17 for the Pomoideae. In the Rosoideae and Prunoideae, and probably in the Spiraeoideae, the larger genera include a series of polyploid species. In several genera which have been extensively studied it has been shown that species differentiation is caused by genetic differentiation of basic sets of chromosomes and by hybridization associated with polyploidy.

In the Pomoideae a few of the larger genera contain many triploids and a few tetraploids, but these forms are probably autopolyploids. The genera of Pomoideae have apparently had a common origin and have developed by genetic differentiation within the basic set of 17 chromosomes.

Many of the genera of Pomoideae are very closely related. *Sorbus* and *Aronia* have similar sets of chromosomes which pair in F_1 hybrids. Generic hybrids are also known to occur between *Crataegus* and *Mespilus*, *Sorbus* and *Amelanchier*, *Sorbus* and *Pyrus*, and *Pyrus* and *Cydonia*. Other genera are morphologically very similar although no generic hybrids are known to exist. The species in the larger genera are often closely related and natural species hybrids are commonly found.



On a genetic and cytological basis of classification all of the present genera of the Pomoideae might be classed as genetic species under one genus. In at least one case two genera should be combined in one species.

Most of the numerous species of *Crataegi* are triploids and are fruitful and breed true apparently due to apogamy or parthenogenesis. Most of these triploid forms are probably the result of polyploidy within a genetic species and should be classed as varieties which breed true by asexual reproduction.

There is some evidence of secondary chromosome association at meiosis which may indicate that the present diploid genera are polyploids with an original basic chromosome number of 7 or 8.

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DESCRIPTION OF PLATE 28

From acetocarmine preparations of pollen mother cells.

- Figure 1. *Crataegus Lavallei*. First metaphase.
2. *Mespilus germanica*. First metaphase.
3. *Cotoneaster horizontalis*. Second metaphase.
4. *Cotoneaster moupinensis*. Diakinesis.
5. *Sorbus Aucuparia*. First metaphase.
6. *Crataegus lawrencensis*. Telophase.
7. *Crataegus lawrencensis*. First metaphase.
8. *Crataegus Deweyana*. Late diakinesis.
9. *Chaenomeles sinensis*. Second metaphase.
10. *Photinia villosa*. Second metaphase.
11. *Aronia melanocarpa*. First metaphase.
12. *Sorbus alnifolia*. First metaphase.
13. *Crataegomespilus grandiflora*. Late diakinesis.
14. *Crataegomespilus grandiflora*. First metaphase.
15. *Crataegomespilus Dardari*. First metaphase.
16. *Amelanchier oblongifolia*. First metaphase.
17-19. *Sorbopyrus auricularis bulbiformis*. Telophase.
20. *Sorbopyrus auricularis bulbiformis*. First metaphase.
21. *Sorbaronia Dippelii*. First telophase.

The bivalents have divided and are shown at each pole in figures 17 and 19, while the lagging univalents are shown in figure 18.

LITERATURE CITED

- BLACKBURN, K. B. (1925). Chromosomes and classification in the genus *Rosa*. (Amer. Nat. 49: 200-208.)
BLACKMAN, K. B., and HARRISON, J. W. H. (1921). The status of the British rose forms as determined by their cytological behavior. (Ann. Bot. 35: 159-188.)

- CRANE, M. B. (1927). Studies in relation to sterility in plums, cherries, apples and raspberries. (Mem. Hort. Soc. N. Y. 3: 119-134.)
- CRANE, M. B., and DARLINGTON, C. D. (1927). The origin of new forms in *Rubus*. 1. (Genetics 9: 241-276.)
- CRANE, M. B., and LAWRENCE, W. J. C. (1930). Fertility and vigour of apples in relation to chromosome number. (Jour. Gen. 22: 153-163.)
- DARLINGTON, C. D. (1928). Studies in *Prunus*. I and II. (Jour. Gen. 19: 213-256.)
- DARLINGTON, C. D. (1930). Studies in *Prunus*. III. (Jour. Gen. 22: 65-93.)
- DARLINGTON, C. D. and MOFFETT, A. A. (1930). Primary and secondary chromosome balance in *Pyrus*. (Jour. Gen. 22: 129-151.)
- ERLANSON, E. W. (1929). Cytological conditions and evidences for hybridization in North American wild Roses. (Bot. Gaz. 87: 443-506.)
- HAGERUP, O. (1928). Morphological and cytological studies of *Bicornes*. (Dansk. Bot. Ark. 6: 1-26.)
- HURST, C. C. (1927). Differential polyploidy in the genus *Rosa*, L. (Verhandl. Cl. V. Int. Kon. F. Vererb. 866-906.)
- ICHIJIMA, K. (1926). Cytological and genetic studies on *Fragaria*. (Genetics 11: 590-604.)
- KOBEL, F. (1927). Zytologische Untersuchungen an Prunoideen und Pomoideen. (Archiv. d. J. Klaus-Stiftung 3: 1-84.)
- LONGLEY, A. E. (1924). Cytological studies in the genus *Crataegus*. (Amer. Jour. Bot. 11: 295-317.)
- LONGLEY, A. E. (1924). Cytological studies in the genus *Rubus*. (Amer. Jour. Bot. 11: 249-282.)
- LONGLEY, A. E. (1926). Chromosomes and their significance in strawberry classification. (Jour. Agr. Res. 32: 559-568.)
- MEURMAN, O. (1929). *Prunus laurocerasus* L., a species showing high polyploidy. (Jour. of Gen. 21: 85-94.)
- MEYER, J. VON. (1915). Die *Crataegomespili* von Bronvaux. (Zeitschr. Ind. Abst. Vererb. 13: 293-333.)
- MORINAGA, T. et. al. (1929). Chromosome numbers of cultivated plants. II. (Bot. Mag. Tokyo 43: 589-592.)
- NEBEL, B. (1929). Zur Cytologie von *Malus* und *Vitis*. (Die Gartenbauwissenschaft 1: 549-592.)
- OKABE, S. (1928). Zur Cytologie der Gattung *Prunus*. (Sci. Rept. Tohoku Imp. Univ. Ser. III, 4: 733-743.)
- PALMER, E. J. (1925). Synopsis of North American *Crataegi*. (Jour. Arn. Arb. 6: 5-128.)
- REHDER, A. (1927). Manual of cultivated trees and shrubs. p. 930. Macmillan Co., New York.
- RYBIN, V. A. (1926). Cytological investigations of the genus *Malus* (Bull. Appl. Bot. 17: 101-119.)
- SARGENT, C. S. (1922). Manual of trees of North America. Houghton.
- SAX, K. (1929). Chromosome behavior in *Sorbopyrus* and *Sorbaronia*. (Proc. Nat. Acad. Sci. 15: 844-845.)
- SHIMOTOMAI, N. (1929). Ueber die Chromosomenzahlen bei einigen Potentillen. (Sci. Rep. Tohoku Imp. Univ. Ser. III, 4: 369-372.)
- TÄCKHOLM, G. (1922). Zytologische Studien über die Gattung *Rosa*. (Acta Hort. Bergiani, 7: 97-381.)
- TISCHLER, G. (1929). Verknüpfungsversuche von Zytologie und Systematik bei den Blütenpflanzen. (Deutsch Bot. Ges. 47: 30-49.)
- TISCHLER, G. (1929). Revisionen früherer Chromosomenzählungen und anschließende Untersuchungen. (Planta 8: 685-697.)
- YARNELL, S. H. (1929). Meiosis in a triploid *Fragaria*. (Nat. Acad. Sci. 15: 843-844.)

CYTOMYXIS

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WHILE making a study of pollen development in *Oenothera gigas* and *O. biennis*, Gates (3) frequently noted an extrusion of chromatin from the nucleus of one pollen mother-cell across plasma strands into the cytoplasm of an adjacent mother-cell. He considered this to be a normal process and called it cytomyxis. Since that time thirty or more cytologists have observed and reported these cytoplasmic strands and chromatic extrusions. A few of the early students considered the process to be normal.

Rosenberg working with *Drosera* (5), Sakamura with *Vicia* (6), Sinoto on *Iris* (7), Yasui with *Papaver* (10), Tischler with *Phragmites* (8), and Erlanson on *Rosa* (2) all think of this nuclear behavior as extremely abnormal and variously suggest that it is due to faulty technique in handling living material, to the action of the fixing fluids or even to pathological conditions. The present tendency has been to agree with the one or other explanation.

Several recent workers (Hicks 4, Church 1, Woodworth 9) who have been studying plant groups mainly from the standpoint of chromosome numbers and abnormalities of the reduction division with a view to detecting plants of hybrid origin, have paid some attention to cytomyxis especially when it involves chromosomes, chromosome groups, and even whole spindles. If such a transposition of chromosomes be normal and the cells in question could function in fertilization, the chromosome number in the gamete would be other than haploid. This would be of some genetic significance. It was thought to be important enough to stimulate further consideration of the normality or abnormality of cytomyxis.

Professor K. Sax has obtained some pertinent data concerning the nature of cytomyxis from a study of smear preparations of pollen mother-cells of *Secale* and other plants. Rye is especially good for such studies because if the end of the anther is cut off the pollen mother-cells may be squeezed out with little change in the normal arrangement of the cells. When such preparations are fixed and stained with aceto-carmin, or fixed in the usual fixatives and stained with crystal violet and iodine, there is little evidence of cytomyxis except at the late spireme stage. The spireme stages do show as high as ten per cent of the cells with chromatin connections but these cases are usually confined to the ends of the string of pollen mother-cells where the anther was cut or where it was pressed in removing the contents. At diakinesis one may occasionally find one or more bivalents which have passed into adjacent cells. At

metaphase and later stages there is no evidence of chromosome migration and the normal chromosome number and arrangement is found in practically all cells.

When the pollen mother-cells are squeezed out of the anther with enough pressure, or smeared with a flat needle after their removal from the anther so that the string of cells is flattened on the slide, "cytomyxis" is found very frequently. In fact under such conditions it is often difficult to find normal spireme stages. Most of the pollen mother-cells have distorted nuclei and chromatic strands between adjacent cells. This may also obtain at diakinesis when chromosomes are extruded into the cytoplasm, into adjacent cells, or into the fixing fluid where they are lost.

Some three hundred slides of the betulaceous catkins which were prepared and studied for chromosome numbers and peculiar behavior (Woodworth 9) were reëxamined for cytomyxis. The anthers which showed this protoplasmic continuity were usually in groups while the surrounding stamens, by far the majority in the catkins, showed no cytomyxis whatever. These aggregations of cytomyctic anthers appeared to be located either where the catkins were held between the thumb and forefinger when their sides were sliced off preparatory to dropping them into the fixing fluid or at a region where the razor blade passed through. The catkins were certainly not handled roughly but it seems that roughness of handling is a relative matter and that the pressure of holding and cutting the catkins must have caused the delicate mother-cells to expel some of their contents. The action of the fixative might contribute to these abnormalities initiated by pressure.

The above conclusion is substantiated by the fact that many species of *Betula* which showed cytomyxis have quite normal meiosis producing perfect pollen. If extrusion of chromatin, especially chromosomes, from one cell into another were a normal process it might reasonably be expected that the pollen grains would be varisized or even sterile in part.

As a check to the foregoing conclusion catkins of some of the species which showed cytomyxis were collected with great care to avoid pressure. These were imbedded and when sectioned showed almost no cytomyxis.

Hybrid plants which have considerable irregularity in the reduction division show the most extreme cases of cytomyxis wherein chromosomes and sometimes even spindles are transposed into adjacent cells. It would seem that some innate unbalance in the heterozygous protoplasm makes it much more susceptible to even slight pressures which would cause the extrusion of chromosomes.

Those students who have seen cytomyxis in the mother-cells of species of plants have not noted the subsequent phases of meiosis to have a deficiency or excess in the chromosome number of any of the cells as an effect of chromosome migration. The evidence now at hand strongly indicates that cytomyxis is not a natural process. Injury to the cells by pressure at the time of preservation seems to account for these cytoplasmic connections and chromatic extrusions.

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LITERATURE CITED

1. CHURCH, G. L., Meiotic phenomena in certain Gramineae. (Bot. Gaz. 88: 63-84. 1929.)
2. ERLANSON, E. W., Cytological conditions and evidences for hybridity in North American wild Roses. (Bot. Gaz. 87: 443-506. 1929.)
3. GATES, R. R., Pollen formation in *Oenothera gigas*. (Ann. Bot. 25: 909-940. 1911.)
4. HICKS, G. C., Chromosome studies in the Cyperaceae, with special reference to *Scirpus*. (Bot. Gaz. 86: 295-316. 1928.)
5. ROSENBERG, O., Cytolog. u. morpholog. Studien an *Drosera longifolia* u. *D. rotundifolia*. (Kgl. Svensk. Vet. Handl. 43: 3-64. 1909.)
6. SAKAMURA, T. Studien über die kernteilung bei *Vicia cracca* L. (Bot. Mag. Tokyo 28: 131-147. 1914.)
7. SINOTO, Y., On the extrusion of the nuclear substance in *Iris japonica* Thunb. (Bot. Mag. Tokyo 36: 99-110. 1922.)
8. TISCHLER, G., Untersuchungen über den Riesenwuchs von *Phragmites communis* var. *Pseudodonax*. (Ber. Deutsch. Bot. Gesell. 36: 549-558. 1918.)
9. WOODWORTH, R. H., Cytological studies in the Betulaceae. (Bot. Gaz. 87: 331-362. 88: 383-399. 1929.)
10. YASUI, K., On the behavior of chromosomes in the meiotic phase of some artificially raised *Papaver* hybrids. (Bot. Mag. Tokyo 35: 154-167. 1921.)

STUDIES IN GANODERMA

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Plates 29 and 30 and Text figure

INTRODUCTION

AMONG my field collections made in the summer of 1929 is a specimen of a *Ganoderma* from a fallen Spruce on an island in Remi Lake, northern Ontario. It is a normal fructification, annual, heavily laccate or varnished above, smooth and shining, rich reddish brown in color, laterally and rather stoutly stipitate. The stipe broadens at its apex, without demarcation, into the pileus; and both are alike in the characters just noted. The context is punky and rather tough, creamy white throughout, except close to the pores,

where it darkens to chocolate brown. The pore layer is uniformly brown. The spores are abundant, and have the wall structure which is characteristic of *Ganoderma*, that is, a smooth and comparatively light epispore, and a dark, thick-walled, echinulate endospore. Apart from the fact that the fungus was growing on Spruce, it would seem to be *Ganoderma lucidum* according to Karsten, or *G. Tsugae* according to Murrill, but which, if either?

Having access to Professor J. H. Faull's collection at the Arnold Arboretum, I found almost identical specimens on Hemlock, Birches, and Oaks from America, and on *Abies* from Europe. I also found there others of curious interest, stalked and sessile *Ganodermas*, annuals and a few perennials, and some taken from the bases of living trees in which the fungus was evidently the cause of a butt rot. My aroused curiosity led me also to examine the copious American collections largely assembled by Dr. W. A. Murrill in the herbarium of the New York Botanical Garden, and the collections especially rich in old world material in the Farlow Herbarium of Harvard University.

One would naturally expect substantial agreement among authorities on the Polyporaceae as to the diagnostic criteria on which the definitions of the commoner north temperate zone species of *Ganoderma* are based. Representative specimens are frequent, they are conspicuous, they carry prolific crops of spores which are available at all times, and they are among the first to find a place in almost every mycological herbarium. One would expect to be able to determine quickly and unerringly the name of such a specimen as the Remi Lake plant from any good manual or paper dealing with the group to which it belongs, but such is not the case.

According to the European manuals this specimen would be referred to *Ganoderma lucidum*. There is not, however, the same unanimity among American authorities. Murrill in his presentation in the North American Flora (12) does not recognize *G. lucidum* as occurring in North America. What appears to be the same thing as the Remi Lake plant is described there under the name *G. Tsugae*, and no other description is applicable. But he affirms that *G. Tsugae* is restricted to Hemlock; while this plant was on Spruce, two hundred miles north of the range of Hemlock. If we consult Atkinson's paper on *Polyporus lucidus* (2) we find closer agreement with the European mycologists; to him it would be *G. lucidum*, though in the matter of nomenclature he prefers the name *G. pseudoboletum*. To Atkinson *G. Tsugae* is not a distinct species. Overholts, in his "Comparative Studies in the Polyporaceae" (15) agrees with neither Atkinson nor Murrill. He does accept *G. Tsugae*

as a good species, under the name *Polyporus Tsugae*, extending the host range to include Pine; but he also recognizes *G. lucidum* under the name *P. lucidus*, in our flora. The latter, however, he finds on hardwoods only. He appears to take no cognizance of the fact that *G. lucidum* in Europe is not so restricted; and *G. lucidum*, as he sees it, is made to include an entirely different plant described by Mur-rill as *G. sessile*. If we follow Overholts, the decision between *G. Tsugae* and *G. lucidum* rests predominantly on the host, that is, whether it be a conifer or a hardwood.

This instance serves as an example of the confusion that exists with respect to conceptions of species of *Ganoderma*, especially in the American flora. Moreover, confusion exists with respect to not only the species, but also the genus itself. A short excursion into the literature soon reveals the fact that the *Ganoderma* of one author is not the *Ganoderma* of another. Interest, therefore, naturally expanded from a diagnosis of the Remi Lake specimen, to the making of a broader survey of the subject, and to the undertaking of more intimate studies. The results are presented in this paper; they include a review of the taxonomic history of the genus *Ganoderma*, a presentation of definitions of what are believed to be some of the valid species in our flora, and an account of the studies on which these definitions are based.

HISTORICAL

1. THE GENUS GANODERMA.

The genus *Ganoderma* was established by Karsten in 1881. In an earlier (1876) systematic work (8), following the Friesian classification of the Polyporaceae, Karsten treated the form which was later to be *Ganoderma lucidum* as *Polyporus lucidus*, the species coming within the Friesian sub-genus *Pleuropus*, which included forms laterally or eccentrically stipitate. The characteristic var-nishing was noted in the specific description. In his (9) "Enumeratio Boletinearum et Polyporearum Fennicum Systemate novo dispositarum" (1881) the new genus, *Ganoderma*, was instituted. The author's conception of it was conveyed rather briefly in a key to the Polypores, and was essentially as follows, translated from the original Latin: "Context white, at times golden yellow, or rarely rose or clay colored. Spores white. [Sporae (omnium?) albae]. Pileus flexible, corky, leathery, or woody. Pileus stipitate. *Ganoderma* n. gen. Pileus and stipe laccate." Only one species, namely *G. lucidum*, was described. Later, in his "Critical Review of the Basidiomycetes of Finland," (1889), Karsten continued to recognize *Ganoderma*, and for the first time gave as synonyms the

"*Polyporus* of other authors in part" and "*Placodes* of Quélet, in part."

It should be explained that *Placodes* as defined by Quélet, (18) comprised woody, persistent forms, with encrusted, sulcate pilei, which in the main are sessile but not infrequently resupinate, or rarely with a tuberculate stipe. Quélet placed *P. lucidus* in an apparently more or less aberrant section of the genus, comprising corky forms with a thinly encrusted surface, colored context, and dark spores. The species was described as having the pileus and stipe "varnished." Quélet's *Placodes* was made by him to include such diverse species as *Polyporus betulinus*, *Fomes applanatus*, and *F. fomentarius*.

It seems probable that Karsten, referring to "*Placodes* in part" as synonymous with *Ganoderma*, had in mind Quélet's section "Suberosi," and in particular that part of it reserved for species with colored spores, in which, to be sure, only *P. lucidus* is found. We must also conclude that subsequent to the time of his earlier work in 1881 when the genus was established, Karsten had become impressed with the peculiar character of the spores of *G. lucidum*, with the result that in his work of 1889, to which reference is made above, he based his description of the genus on spore characters, and did not refer to the varnishing of the pileus and stipe which earlier had been the generic criterion. Hence we are in some doubt as to the essential criteria of *Ganoderma* as conceived by Karsten, and this uncertainty has at least contributed to the difficulties in interpreting the genus which others have experienced in working with forms representative of a much wider geographical range.

This leads us naturally to a consideration of the work of Patouillard, whose collections were representative of a much wider field. Karsten confined himself solely to temperate Europe, while Patouillard gave his attention to tropical collections as well. In his study "*Le Genre Ganoderma*" (17), which appeared the same year as Karsten's later studies of the Polyporaceae of Finland, Patouillard emphasized the importance of spore characters in the study of the taxonomy of the Polypores. He referred to Karsten's original definition of the genus *Ganoderma*, but considered that there were many forms other than *G. lucidum*, which, chiefly on the evidence of similar spore structure, properly belonged in the same group. Patouillard included in the genus those forms characterized by a more or less colored context, and a rigid brittle crust which is more or less shiny, either smooth or rimose and formed of thickened hyphal elements. The spores of the included species are brown or yellowish, ovoid to globose, either smooth or asperulate, and some-

times with thickened or cuticularized walls. He also stated that some of the forms are annual, while others are persistent, and that they may be sessile or stipitate. Patouillard described about 50 species, which were sub-divided into two groups—the first, sub-genus *Ganoderma* *vrai*, having ovoid spores, and sporophores with a shiny, well varnished crust; and the second, which is composed of tropical and sub-tropical species, sub-genus *Amauroderma*, having globular to subglobular spores, and sporophores with little if any surface varnishing. Thus through his desire to include in the genus *Ganoderma* all those species which have one, or both of the characters of varnishing and “rough” spores, Patouillard was led to extend its bounds much beyond what we must consider to have been the original conception of the genus.

Turning to American authorities, we find that Murrill gives the essential character of *Ganoderma* simply as a reddish brown varnishing of the surface of the sporophore, thus holding rather closely to Karsten’s original description. In his treatment in North American Flora, he makes a new genus of Patouillard’s sub-genus *Amauroderma*, to include epixylous, stipitate, encrusted, but not varnished forms, with ovoid to globular brown spores. The species in North America are confined to the tropics or sub-tropics.

Miss Ames (1) follows somewhat the treatment of Patouillard. Her conception of the genus is broad. Its essential characters are a fruit body with a heavily encrusted upper surface, which might be either of the “palisade” type noted by Patouillard, as in *G. lucidum*, or of the “interwoven” type as in *Fomes applanatus*. Varnishing is not considered an essential character. The spores must be smooth, pale to dark brown, with a “wall perforated with darker lines”—a description which was derived from Atkinson’s account, based on his careful observations, of the structure of the spore. Inconsistently, Miss Ames includes such species as *Fomes fomentarius*, which we now know possess spores with simple, smooth walls. Presumably, with regard to such, she had not seen their spores, and mistakenly assumed that they were of the *Ganoderma* type.

For the sake of easier comparison of the criteria of *Ganoderma* as conceived by the several authors who have treated the genus, the essentials of their descriptions are arranged in tabular form on page 30:

DESCRIPTIONS OF GANODERMA

Author	Habit	Persistence	Context	Crust		Spores
				Surface	Structure	
Karsten* †	stipitate —	— —	— —	varnished —	— —	— ovoid, warty, yellow-brown
Patouillard	stipitate or sessile	annual or perennial	—	brittle, shiny, smooth or rimose	formed of thickened hyphal elements	ovoid to glo- bose, yellow or brown, smooth or asperulate
Murrill	stipitate or sessile	annual or perennial	brown or pallid	varnished red or brown	—	ovoid, brown
Ames	stipitate or sessile	annual or perennial	fibrous to corky or woody; pale to dark brown	hard, sometimes varnished	—	smooth, wall perforated with darker lines; pale to dark brown

* Karsten 1881.

† Karsten 1889.

2. TAXONOMIC HISTORY OF CERTAIN SPECIES

(a) *Ganoderma lucidum* (Leys.) Karst.

The synonymy of *Ganoderma lucidum* (Leys.) Karst. is recorded by Atkinson (2) under *G. pseudoboletus* (Jacq.) Murrill quoted incorrectly by him as *G. pseudoboletum* as follows:

Agaricus pseudoboletus Jacquin, Flor. Aust. 1: 26–27. pl. 41 (1773).

Boletus rugosus Jacquin, Flor. Aust. 2: 44. pl. 169 (1774).

Boletus obliquatus Bulliard, Herb. France, pl. 7 (1780).

Boletus lucidus Leysser, Flor. Halensis. 300 (1783).

Polyporus lucidus Fries, Syst. Myc. 1: 353 (1821).

Polyporus laccatus Persoon, Myc. Eur. 2: 54 (1825).

Ganoderma lucidum (Leys.) Karsten, Rev. Myc. 3: no. 9, p. 17 (1881).

Ganoderma Tsugae Murrill in Torr. Bot. Club, 29: 601 (1902).

It was on a specimen of this form that Karsten based the genus. The distinctive fructifications had long been recognized throughout Europe and occur there commonly. All the European descriptions allow for considerable variation in habit, shape, color, and also host range. Thus Fries (6) describes *Polyporus lucidus* as with or without stipe, the position being central, eccentric, or lateral,—in which case the pileus is reniform. The color is light yellow when young, chestnut or almost black when mature. The occurrence is on the trunks of Oaks and other trees in Europe, Asia, Japan, and North America. In the Exsicc. Karst. Fung. Fenn. 1865, no. 239, *Polyporus lucidus* Leys. is reported as occurring on *Quercus*, *Alnus*

glutinosa, and *Abies excelsa*. In Krieger's collection there is a specimen from Birch. Others have collected it from Willow, and as Karsten himself reports, specimens have been collected from conifers.

While European taxonomists are substantially in agreement on *Ganoderma lucidum* in Europe, American authorities on the other hand hold very diverse views of the species, both as to host relationships and morphological characters. There are three prevailing American conceptions as represented by Atkinson, Murrill, and Overholts.

Considering host relationships first, Atkinson holds that *Ganoderma lucidum* occurs in the American flora, but he surmises that there are various strains of the species both here and in Europe. From first hand observations, he holds that there are two distinct strains in Europe. He calls attention to a very dark form on Firs in the Jura mountains, and to a lighter form on the other hosts. The latter he designates as *G. pseudoboletum typicum*, and the former as *G. pseudoboletum* var. *montanum* Atk. He likewise recognizes two forms in America, one growing on Hemlock (Murrill's *G. Tsugae*), which he designates *G. pseudoboletum* var. *Tsugae* Atk., and a second one found on other hosts, but especially hardwoods, which he calls *G. pseudoboletum typicum*, though probably not the typical *G. lucidum* of Europe. Murrill at first considered *G. lucidum*, the typical European form, which he preferred to call *G. pseudoboletus*, to be represented in America (11) and reported it as occurring on Oak, Alder, Hazel, Maple, Willow, Honey Locust, Sweet Gum, and Beech, throughout Europe, and in England, Australia, and America. In his later work (12) (13) reference to the species is omitted, and although we do not know what disposition was made of the numerous American collections previously reported by him, we must believe that Murrill came to the conclusion that the American forms were distinct, and that *G. lucidum* does not occur in America. Overholts (15), voicing a third viewpoint, believes that *G. lucidum*, which he calls *Polyporus lucidus*, is an American as well as a European species, and that it is found generally throughout the eastern part of the United States on the trunks and roots of deciduous trees. He does not recognize it, however, as occurring on conifers; for such he adopts Murrill's name *G. Tsugae* (*Polyporus Tsugae*), though with wider significance (15).

The American authorities are likewise almost as far apart in their notions of habit, shape, and color, as in the matters of name and hosts. This has naturally followed from the circumstance that there has been no agreement as to the limitation of the species, and

also because there has been so often no clear differentiation between variable and constant characters.

(b) *Ganoderma sessile* Murr.

This species was originally described by Murrill (11) as a sessile form occurring on deciduous trees. It was stated to differ from *G. lucidum* in having an acute margin, a more rugose surface and in being always without a stipe. This first description was subsequently much modified, so that in "Northern Polypores" (13) we find *G. sessile* described as either sessile or laterally stipitate, and as occurring on conifers or hardwoods. From the later descriptions of this species we gather that the characteristic features of the fruit body are its reddish chestnut color, more or less zoned surface, an acute margin and a fibrous context. The author states that it resembles *Polyporus lucidus* of Europe, but considers that *G. sessile* is an indigenous American plant. Overholts (14) considers it synonymous with *G. lucidum*, and Atkinson makes no mention of it. It is appropriate to refer here to *Ganoderma subperforatum* Atk., which was described by Atkinson in 1908 on the basis of a single specimen collected in Ohio. Having become impressed with the peculiar structure of the spore in *Ganoderma*, it was noticed that in this specimen the walls were relatively thin and the echinulations of the endospore reduced. This feature, and also the fact that although stipitate the occurrence was on Oak led Atkinson to consider it a hitherto undescribed species. When Murrill revised *G. sessile* so as to include stipitate forms, he considered *G. subperforatum* as probably identical. Overholts, on the other hand, considers it identical with *Polyporus lucidus*. After studying the type specimen, a privilege extended through the courtesy of the custodian of the Atkinson Herbarium, I have no hesitation in expressing agreement with Murrill's disposition of it. It is a *Ganoderma sessile*.

(c) Murrill's *Ganoderma Tsugae*

The chief characteristic of *Ganoderma Tsugae* Murr. that sets it apart from other species of *Ganoderma*, according to its author, is its host specificity for Hemlock. There are other characters noted, to be sure, but they are not of the same determinative value. In comparison with the later descriptions of *G. sessile*, the significant features seem to be a darker colored, non-zonate top, a softer context, perhaps a less acute margin, and a concave rather than a convex lower surface. Atkinson recognizes *G. Tsugae* simply as a form of *G. lucidum*. He states that in color and other characters it differs but slightly if any from the typical form, and only its host specificity

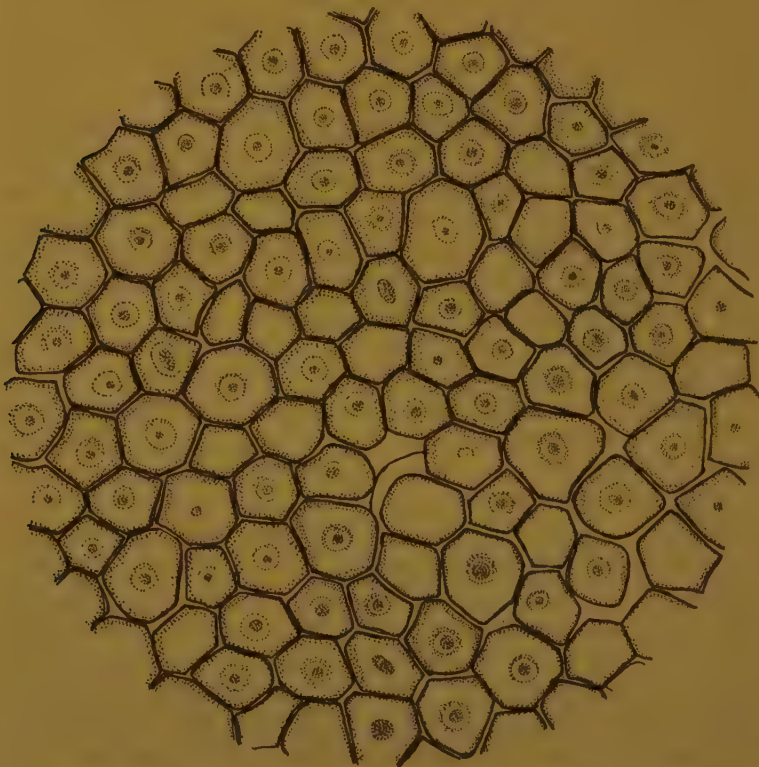
distinguishes it. According to Overholts (15) on the other hand, *G. Tsugae* cannot be differentiated by host affiliation alone, as it is found growing on and about the stumps of Pine as well as Hemlock. Overholts considers this a good species, however, recognizing in the context a distinctive structure and color and manner of branching of the hyphae, all of which, it is held, are characteristic of this form only, and serve to distinguish it from its close allies. The present writer can confirm this only in part. All the specimens which he has examined from Hemlock do display a context which in macroscopic and microscopic features answers to the description by Overholts, but many of the European collections of *G. lucidum* have these same characters, and cannot be distinguished on this basis. Similarly among Professor Faull's collections is a specimen from an oak stump which has the typical context of *G. Tsugae*, and in the herbarium of the New York Botanical Garden there is a collection from a maple log which cannot be distinguished from *G. Tsugae*, and which in fact is labelled such. Although as far as is known the specimens on Hemlock have always the same kind of context, this by no means serves to separate them from all other species.

In view of the obvious confusion which exists in regard to these species, one is led to seek an explanation. The writer believes that it is due at least in part to the assumption of host specificity, and the recognition of species on this basis. This assumption is not supported by proof. It is of course true that in the case of many of the Polypores certain hosts are favored, but in this group one is hardly justified in characterizing a species as host specific. Whether in certain species there are biological strains in which strict host specificity is developed is a possibility which in this group still remains to be demonstrated. One must, therefore, rely as yet on morphological characters alone as the basis on which species are to be recognized, and these possibilities are by no means exhausted in the case of the species under discussion. Important morphological differences are to be found in the crust and in the spores. They will probably also be found in the mycelial mats of pure cultures grown on artificial media.

CRITICAL STUDIES OF THE CRUST

In order to study the structure of the crusts of the sporophores, it was found necessary to prepare vertical and transverse sections. Since the varnish which covers the mature fruit body as a thin fragile pellicule dissolves rapidly in alcohol and xylol, the usual embedding methods could not be employed. The best sections showing the varnish were prepared by infiltrating with a soap solution

small blocks of the crust capped context under a reduced pressure. The material was embedded in soap, the water being evaporated off as rapidly as possible. Soap solution will gradually dissolve the varnish, but if the infiltration and embedding are done rapidly good sections can be secured. The temperature must not be high, otherwise the varnish will be melted.



Transverse section through the palisade elements of the crust of *G. oregonense* ($\times 800$).

Though showing considerable specific differences, the crusts of all our *Ganodermas* have certain features in common. They are seen to be composed of the enlarged and somewhat bulbous ends of hyphae growing out from the context. These are arranged very compactly together in the vertical position; and they form a sort of palisade layer, over the surface of which is the hardened varnish, resembling a thick fragile cuticle. The hyphal elements which together compose the crusts are typically very thick walled, and appear to be impregnated with the dark orange varnishing substance

which they have secreted. In cross section they are angular, frequently pentagonal or hexagonal, and are surprisingly uniform in shape and size. They are without surface pores, and it is only with difficulty that a central canal or lumen can be made out. The walls appear to be thickened concentrically, until the elements are practically solid. Their color is a rich orange yellow, which penetrates uniformly to a depth somewhat below that of the base of the palisade layer into the thick-walled threads of the context. In very thin sections the color is faint yellow.

(a) *Ganoderma oregonense* Murrill

This species has a crust which is darker in color, thicker, and of more regular structure than the crust of any other species studied. The club-shaped elements of which it is composed are from 50 to 60 μ in length and from 6 to 10 μ in diameter. In thin sections the color, which is orange yellow, is seen to penetrate from the surface to a depth of as much as 275 μ . In specimens which have developed favorably the varnish may be 15 μ thick. See Fig. 16.

(b) *Ganoderma lucidum* (Leys.) Karst.

In the case of this species, which is taken to include *G. Tsugae* Murr., the crust differs from that of *G. oregonense* only in being composed of slightly shorter bulbous elements, which are sometimes not as regularly arranged, and in having a thinner coat of varnish. In *G. oregonense* the hyphae approaching the crustal layer are rather straight and uniform, while in *G. lucidum* they are usually crooked, tangled, and of varying diameter. This feature in *G. lucidum*, however, is by no means constant. The character of the crust is doubtless determined to some considerable extent by the nature of the conditions under which the sporophore comes to maturity. In *G. lucidum* the bulbous elements of the crust are about 40 μ long, and from 6 to 8 μ in diameter. The varnish is commonly about 12 μ thick. The crust of a typical *G. lucidum* is illustrated in vertical section in Fig. 8.

(c) *Ganoderma Curtisii* Berk.

This species is usually described as partially varnished or with varnish coming off in flakes. An examination of the crust reveals the interesting fact that the whole of the palisade layer exfoliates leaving the sporophore with a chamois-like surface of densely woven fine hyphal ends. The crust of this species is comparatively thin. The palisade elements are bulbous and commonly from 15 to 25 μ long. They arise from a stratum of densely woven fine hyphae, which constitutes a plane of weakness along which the separation

of the crust from the sporophore takes place whenever the former is shed in irregular flakes. Not infrequently there are thin-walled elements, such as are observed at the growing margin of all species, interspersed among those with thickened walls. This feature is one never observed in other species. Spores may be found embedded in the crust. In *G. Curtisii* the total thickness of the crust including the varnish is about 30 μ . See Fig. 18.

(d) *Ganoderma sessile* Murrill

In *G. sessile* the crust is distinctly different from that of other species. The palisade elements are bulbous rather than club shaped and, although forming a dense compact stratum, are not as closely and uniformly fitted together as in the case of *G. lucidum* or *G. oregonense*. The crust is thinner than in those species, the bulbous elements being from 15 to 30 μ in length. The coating of varnish is distinctly thinner, being about 8 μ in depth. See Fig. 12.

CRITICAL STUDIES OF THE SPORES

The spores of *Ganoderma* differ from those of most of the other Polypores not only in being brown in color, but in appearing to be rough or warty superficially. Actually, they are smooth, but the peculiar structure of the walls lends an appearance of roughness, so that in the early descriptions they were described as warty, rough, echinulate, or spiny. Patouillard was the first to draw attention to the double wall of the spore, the inner of which was described as being echinulate and comparatively thick, the outer as thin, and "moulded exactly on the points of the endospore." More careful observations have shown this description to be not entirely correct. It was Atkinson (2) who first pointed out that the exterior surface of the spore wall is perfectly smooth. His deductions, however, as to the structure and development of the walls, although not stated in positive terms, were erroneous in that, not conceiving of the wall as essentially duplex, he considered the spines or echinulations of the endospore to be extensions of the brownish spore content. White (21), referring to the similar spores of *Fomes applanatus*, observed that Atkinson's interpretation was incorrect, and stated that within an original hyaline wall a "rough coated, thick, and yellow walled endospore is formed." While the nature of the outer wall of the mature spore was not clearly described, subsequent work has shown White's interpretation to be essentially correct. It remained for Coleman (4) to describe in detail the development of the duplex wall. He found that the endospore wall originates from granules laid down on the inner margin of the episporium, that these increase in size and fuse to form a membrane which thickens

and develops spines, and that the latter penetrate the thick, softer episore while it is still plastic. Coleman also demonstrated chemical differences in the episore and the endospore by means of staining and microchemical tests.

The phylogenetic significance of the *Ganoderma* type of spore is a subject beyond the scope of this paper. It is surprising, however, that more attention has not been devoted to it, and that more use has not been made of spore characters in classification.

Believing that there might be significant differences in the spores which would be of value in specific diagnosis, the writer examined spores from many American and European specimens. It soon became apparent that within the *Ganoderma* type, two distinct sub-types could be readily identified, which are distinguished by the thickness of the walls, particularly of the endospore wall, and the length and the number of spines projecting from it. Thus the superficial appearance of the spore of one is distinctly thick-walled and very rough, while that of the other is comparatively smooth, the double wall and the spines being made out only with difficulty under high magnification. These differences in the spores of *Ganoderma* have already been noted by others, but little importance has been attached to them. Patouillard, in describing the spores of his new species *G. carnosum*, says that they are a little larger and rougher than those of *G. lucidum*. Atkinson, likewise, for his species *Ganoderma subperforatum*, stated that its spores are distinctly smoother than those of *G. lucidum*; he embodied this observation in the specific appellation *subperforatum*. The writer's observations on the spores of various species of *Ganoderma* are summarized below.

(a) *Ganoderma oregonense* Murrill

The spores of *G. oregonense* are larger than those of any eastern North American species. They range in size from 7.4 by 11.9 to 8.4 by 14.0 μ . They are thick-walled and heavily echinulate on the endospore surface, the echinulations, however, being spaced rather far apart. Thus the spores appear exceedingly rough. See Fig. 17.

(b) *Ganoderma Curtisii* Berk.

A striking feature of the spores of *G. Curtisii* is their great variability in size and shape. Those measured by the writer ranged in size from 4.8 by 9.5 to 6.3 by 11.2 μ . The shape is from almost symmetrically ovate to sub-allantoid. Even from the same specimen spores differing considerably in size and shape are found. They are of the thick-walled "rough" type. See Figs. 19 and 20.

(c) *Ganoderma lucidum* (Leys.) Karst.

The spores of typical specimens of this species are also of the thick-walled, heavily echinulate type. They range in size from 6.3 by 7.7 to 9.8 by 11.9 μ . Included here are those forms commonly found on Hemlock (Murrill's *G. Tsugae*), the spores of which are indistinguishable from those of *G. lucidum* on hardwoods. The Remi Lake specimen, to which reference has frequently been made in this paper, proves also to be representative of this species in spore characters as in others. See Figs. 9, 10 and 11.

As for the so-called *G. Tsugae*, it is apparent that the Hemlock is a particularly suitable host for this form, but there seems to be no reason for regarding it as a distinct species. Identical forms are known to grow on Birch, Maple, Spruce and other hosts. In this connection it is interesting to note that although not found in Europe at the present time, the Hemlock occurs there in Eocene deposits (7) (20), and that it probably persisted in Europe and in northern latitudes between Europe and America until the Pleistocene.

(d) *Ganoderma sessile* Murrill

In *G. sessile* the spores differ from those of the species enumerated above in being relatively thin-walled. The endospore has numerous short delicate spines, which can be observed only with difficulty under high magnification. This character at once distinguishes *G. sessile* from its close allies. The spores are of approximately the same size as in *G. lucidum*. See Figs. 13, 14 and 15.

Ganoderma subperforatum Atk. is identical with *G. sessile* Murr. Had Atkinson been familiar with the spore characters of Murrill's *G. sessile*, he would probably have placed his specimen there instead of creating a new species, because it shows the same spore characters as those possessed by the spores of *G. sessile*.

Continuing the subject of spore characters, it was with considerable interest that the writer examined the European collections labelled *G. lucidum* in the Farlow Herbarium. It was found that these specimens could be readily separated into two groups on the basis of the character of the spore wall, and that those with relatively thin walls and with numerous fine echinulations on the endospore (the "smooth" type) resembled closely in gross features the American *G. sessile*, while the "rough" spored specimens resembled the American *G. lucidum* (including *G. Tsugae*). To which group the type specimen of *G. lucidum* belonged it has been impossible for the writer to determine, since type material was not available. It is to the point, however, to state that Karsten's specimen number

239, which he quoted as the type of the new genus *Ganoderma*, is represented in the Farlow Herbarium by a duplicate collection bearing the same number, and that this specimen has spores which are thick-walled and coarsely echinulate on the endospore surface. Moreover, going back to Jacquin's original description of *Agaricus pseudoboletus* (in *Flor. austr.* 1: 26-27. pl. 41. 1773; and 2: 44. pl. 169. 1774), and Leysser's account of *Boletus lucidus* (in *Flora Halensis*, 300. 1783; and figured in Curtis, *Flora Londinensis* 4. pl. 224, original edition), we find that the sporophores before these authors were stalked. The resemblance was to that of the sporophores so common in America on Hemlock, and not to Murrill's *G. sessile*. I may also add that in order to get an idea as to whether or not this is a form frequent in Austria, I have examined the specimens of *Ganoderma* found in the von Höhnelt collections, now stored in the Farlow Herbarium. All of the plants collected by von Höhnelt around Vienna as represented in this herbarium are rough spored, and the stalked form would seem to be the prevailing type. On the other hand it is clear that in Europe there also exists a form similar to or identical with *G. sessile* Murrill, and that it differs essentially from what we consider to be *G. lucidum*. The writer, therefore, unhesitatingly concludes that *G. lucidum* and *G. sessile* are distinct species, each of which is found both in Europe and America, and that they answer to the descriptions given below.

DESCRIPTION OF SPECIES

By way of summary, I have ventured to re-define the species studied in this paper as follows:

***Ganoderma lucidum* (Leys.) Karst.**

Sporophore stipitate, stipe lateral, ascending, or short-tuberculate, rarely sessile, annual, rarely perennial; pileus dimidiate or reniform, convex above, plane or concave below; margin plane to broadly lobed, sometimes wavy when dry, surface smooth becoming wrinkled and furrowed when dry, heavily laccate, lustrous, cherry red to deep mahogany or almost black; stipe as in pileus; context felty to corky, or rarely radiate fibrous, light in color except close to tubes; hyphae of context hyaline, frequently branched, rather crooked; tubes cinnamon brown to umber, 3-5 per mm.; crust of vertical solid palisade hyphae, dense and compact, about 40 μ long; varnish 10 to 12 μ thick; spores ovoid, slightly asymmetrical on vertical axis, light brown, smooth, but appearing rough, walls thick; endospore coarsely echinulate with relatively few spines; spores 6.3 by 9.8 to 7.7 by 11.9 μ .

On hardwoods and conifers. In America most commonly on Hemlock. *G. Tsugae* is a synonym. See Figs. 1, 2, 3, 8, 9, 10, and 11.

***Ganoderma sessile* Murrill.**

Sporophore sessile, rarely stipitate, annual (rarely perennial?); pileus dimidiate to semi-circular, plane to slightly convex above, usually plane to convex below, usually thick behind; margin acute; surface smooth or irregular, frequently zonate, thinly laccate, lustrous to dull when dry, light brick red to brownish red; margin often lighter tending to yellowish; context radiate fibrous, of two distinct layers, the upper light brown, the lower cinnamon to chocolate brown; hyphae hyaline to brownish, uniform, usually branching infrequently; tubes cinnamon brown to umber; mouths whitish to umber, glaucous where not bruised, 3–5 per mm.; crust of vertical palisade hyphae, compact, but not as dense as in *G. lucidum*, about 30 μ long; varnish 6 to 8 μ thick; spores ovoid, slightly asymmetrical on vertical axis, light brown, smooth, walls thin, endospore finely echinulate with numerous delicate spines seen with difficulty; spores 6.3 by 10.5 to 7.0 by 11.6 μ .

In North America and Europe on deciduous leaved trees (rarely on conifers?). *Ganoderma subperforatum* Atkinson is a synonym. See Figs. 4, 5, 12, 13, 14, and 15.

***Ganoderma Curtisii* (Berk.) Murrill.**

Sporophore stipitate, stipe lateral, eccentric or central, annual (or perennial?); pileus reniform to circular, convex or depressed; margin usually thick and abrupt when mature; surface smooth, thinly laccate, often zonate, yellowish brown or orange, with olive tinge when scratched; stipe with persistent varnish, yellowish brown to brick red; context of two layers, the upper light, the lower dark chocolate brown, felty to radiate fibrous; tubes cinnamon brown to umber, mouths whitish; crust of vertical bulbous hyphae, some solid, others empty, of irregular size and height, about 20–25 μ long; crust frequently peeling off, leaving surface dull cream or yellowish; varnish 6 to 8 μ thick; spores variable in size and shape, mostly long ovoid, sometimes distinctly curved; light brown, smooth, appearing rough, walls thick, the endospore being coarsely echinulate with few spines; spores 4.8 by 9.5 to 6.3 by 11.2 μ .

In southeastern North America. Reported only on hardwoods. See Figs. 6, 18, 19, and 20.

***Ganoderma oregonense* Murrill.**

Sporophore stipitate with short thick lateral stipe or almost sessile; annual; pileus convex above, usually concave below, relatively thick; margin regular or wavy, rather acute, often with a

furrow close to the edge and paralleling it; surface smooth, heavily encrusted and laccate, dark bay to black; context thick, soft, felty, light buff, deepening in color near the tubes, often with tissue of white mycelium irregularly disposed in lower part near stipe; tubes long, 3 to 5 per mm.; crust of vertical solid palisade hyphae, dense and compact, 50 to 60 μ long; varnish heavy, 15 to 20 μ deep; spores ovoid, slightly asymmetrical, light brown, smooth, with echinulate thick walled endospore; spines coarse and relatively few; spores 7.4 by 11.9 to 8.4 by 14.0 μ .

On conifers in western North America. See Figs. 7, 16 and 17.

This species was first described by Murrill in North American Flora, at which time it was known only from the type locality in Oregon. It is now known to occur generally on the Pacific slope, and has been collected on a number of conifers besides *Picea sitchensis*, on a log of which it was first found. It bears a close resemblance to Atkinson's *G. pseudoboletum* var. *montanum* but has definitely larger spores.

SPECIMENS STUDIED

(a) *Ganoderma oregonense*.

HERBARIUM J. H. FAULL: specimen 3691 on *Tsuga heterophylla*, Sonora Island, British Columbia; spec. 6706 on Douglas Fir, Royston, B. C.; spec. 9355 on conifer, Vancouver, B. C.

HERBARIUM NEW YORK BOT. GARD.: spec. 6 (*type*) on old log of *Picea sitchensis*, near Seaside, Oregon; spec. coll. by H. D. House, Martha's Lake, near Everett, Wash.

(b) *Ganoderma Curtisii*.

HERBARIUM J. H. FAULL: spec. 3568 on Oak, Thomasville, Ga.; spec. 3682 on dead hardwood, Pinehurst, N. C.; spec. 175.

HERBARIUM NEW YORK BOT. GARD.: spec. 4389 on dead wood; spec. on dead Oak, Biloxi, Aug. 31, 1904. E. G. E.; spec. on *Quercus rubra* stump, Alliston, Mo.; spec. coll. by B. B. Higgins, Experiment, Ga.; spec. 545 ex. Herb. A. Commons; spec. coll. by W. A. Murrill, Biltmore, N. C., Oct. 1907; spec. coll. by Edwin Fowler, on root of Maple, Trenton, N. J., labelled *G. sessile*.

(c) *Ganoderma lucidum*.

HERBARIUM J. H. FAULL: spec. 181 *G. lucidum*, on *Betula alba*, Toronto, Ont.; spec. 183 *G. lucidum* on Oak stump, Toronto; spec. 182 *G. lucidum*, on *Betula lutea*, Wilcox Lake, Ont.; spec. 179 *G. lucidum* forma *montanum*, Vosges,

France, ex Herb. G. F. Atkinson, 21077; spec. 9718 *G. lucidum*, on fallen Spruce, Remi Lake, Ont.; spec. 185 *G. Tsugae*, on *Tsuga canadensis*, Toronto, Ont.; spec. 3470 *G. Tsugae* on *Tsuga canadensis*, East Angus, Prov. Quebec; spec. 5422 *G. Tsugae* on *Tsuga canadensis*, Algonquin Park, Ont.; spec. 1579 *G. Tsugae* on *Tsuga canadensis*, Toronto, Ont.

HERBARIUM NEW YORK BOT. GARD.: spec. 645 *G. Tsugae* coll. by W. A. Murrill, Aug. 7-10, 1904; spec. 1157 *G. Tsugae* on Maple log, Cadillac, Michigan; spec. on decaying stumps of Hemlock; spec. 2529 *G. Tsugae*; spec. 11 *G. Tsugae* coll. by A. H. Mackey, Nova Scotia; spec. 3281 *G. Tsugae* on *Tsuga canadensis*, Sturgis, W. Va.; spec. 536 on old log in Rhododendron Valley coll. by W. A. Murrill, labelled *G. sessile*.

FARLOW HERBARIUM (all labelled *G. lucidum*): Fung. Fenn. 239 (Karsten); Fung. Gall. 180 (Roumerguère); Fung. Brit. 2nd. Ed. 101 (Cooke); Fung. Brit. 1st. Ed. 603 (Cooke); Myc. March. 2106 (Sydow); Fung. Sax. 1116 (Krieger).

(d) *Ganoderma sessile*.

HERBARIUM J. H. FAULL: spec. 9335 *G. sessile* on *Acer saccharinum*, Cambridge, Mass.; spec. 1221 *G. sessile* on living *Ulmus americana*, Port Credit, Ont.; spec. 1551 *G. sessile* on living *Ulmus americana* Port Credit, Ont.; spec. 180 *G. sessile* on Elm stump, Ithaca, N. Y.; spec. 9525 *G. sessile* on living *Fraxinus americana*, Cambridge, Mass.

ATKINSON HERBARIUM in the New York State College of Agriculture: spec. 19560 *G. subperforatum* Atk. (type).

HERBARIUM NEW YORK BOT. GARD.: spec. 734 *G. sessile* ex Herb. G. Commons; spec. 2575 by stump of *Acer rubrum*, Gold Station, Md.; spec. 1430 *G. sessile*; spec. 1435 *G. sessile*; spec. 1 ex. Herb. L. O. Overholts; spec. 446 ex Herb. N. M. Glatfelter on Black Oak, St. Louis; spec. from Miss Sadie F. Price, Bowling Green, Ky.; spec. 2323 ex Herb. A. P. Morgan; spec. 32 *P. lucidus* Leys., Cincinnati, Ohio; spec. marked *G. sessile* type, from old Oak stump, Bedford Park; spec. *G. sessile* on Red Maple stump, N. Y. Bot. Gard. autumn, '08; spec. 25 *G. sessile* typical; spec. *G. sessile* on partly dead trunk *Acer rubrum*, on road from Clason's Point to Unionport, New York City; spec. 2507 Flora Ludoviciana legit A. B. Langlois, St. Martin's Ville, La.; spec. *G. sessile* on Norway Spruce stump, coll. W. A. Murrill and P. Wilson, Williams Bridge, New York City.

HERBARIUM RUSH P. MARSHALL: spec. on *Tilia americana*, Washington, D. C.; spec. on *Ulmus americana*, Andover, Mass.; spec. on *Acer saccharum*, Glastonbury, Conn.

FARLOW HERBARIUM (the following are labelled *G. lucidum*): Myc. Univ. 104 (de Thümen); Erb. Critt. Ital. series I 769; Fung. Europ. 1213 (Rabenhorst); Myc. Venet. 9 (Saccardo).

ADDENDUM

The following table shows the dimensions of spores of most of the species of *Ganoderma* recorded in the North American Flora, other than those studied in this paper, as determined by the writer from specimens in the Herbarium of the New York Botanical Garden:

Species	Dimensions	Dimensions given in the North American Flora
<i>G. Sequoiae</i>	6.7-7.4 x 11.9-14.2 μ	none
<i>G. nevadense</i>	7.4 x 11.9-13.4 μ	none
<i>G. oregonense</i>	7.4-8.4 x 11.9-14.0 μ	none
<i>G. sulcatum</i>	5.9 x 11.9-12.6 μ	4-4 x 8-10 μ
<i>G. nitens</i>	7.4-8.2 x 10.4-11.9 μ	none
<i>G. tuberculosum</i>	7.4-8.2 x 9.7-11.2 μ	6 x 8 μ
<i>G. zonatum</i>	5.2-5.9 x 10.4-11.2 μ	4-6 x 8-10 μ
<i>G. subincrustatum</i>	6.7-7.4 x 9.7-11.2 μ	4 x 8 μ
<i>G. sessileforme</i>	5.9-6.7 x 8.9- 9.7 μ	none
<i>G. argillaceum</i>	5.2-6.3 x 8.9-10.4 μ	7 x 12 μ
<i>G. subfornicatum</i>	5.2-5.9 x 9.7-10.4 μ	4 (globose) μ
<i>G. stipitatum</i>	5.2-5.8 x 7.4- 8.2 μ	3.5 x 5 μ

Many of the foregoing are represented by specimens from the type locality only. The species can be grouped according to the character of their spores, whether resembling those of *G. sessile* ("smooth" type) or those of *G. lucidum* ("rough" type), as follow:

Species having thin-walled spores; the echinulations of the endospore fine	Species having thick-walled spores; the echinulations of the endospore coarse
<i>G. argillaceum</i>	<i>G. Sequoiae</i>
<i>G. sessileforme</i>	<i>G. nevadense</i>
<i>G. sulcatum</i>	<i>G. nitens</i>
<i>G. subincrustatum</i>	<i>G. tuberculosum</i>
<i>G. zonatum</i>	
<i>G. stipitatum</i>	
<i>G. subfornicatum</i>	

The writer is indebted to Professor J. H. Faull for suggesting the subject and for direction throughout this research. He is also under obligations to the curators of the Herbarium of the New York Botanical Garden, and of the Farlow Herbarium for affording free use of their collections.

SUMMARY

1. The history of the genus *Ganoderma* is briefly reviewed and attention drawn to the diversity of opinion in regard to the limitations of the genus, a situation due to the inadequacy of the original description and various subsequent modifications. Based on the distinctive organization of the crustal layer of the sporophore, and the remarkable structure of the spores, the genus is a well defined one.

2. The distinctive features of the crust are a peculiar "palisade" layer composed of modified hyphae, and a resinous cuticle which is secreted superficially.

3. The spores are smooth externally, though appearing rough from the numerous echinulations of the endospore.

4. Two sub-types of spores are recognized, (1) those with thick walls and relatively few, coarse echinulations on the endospore, and (2) those with thinner walls, and many finer echinulations on the endospore. The spores of any given species are of one type only.

5. The morphological characters of the sporophores, particularly of the crust and spores, are of paramount importance in the determination of species. According to our present knowledge there is no justification for assuming strict host specificity in this group; such an assumption in the past has led to erroneous specific determinations.

6. These studies have been confined to four temperate zone species as follows:

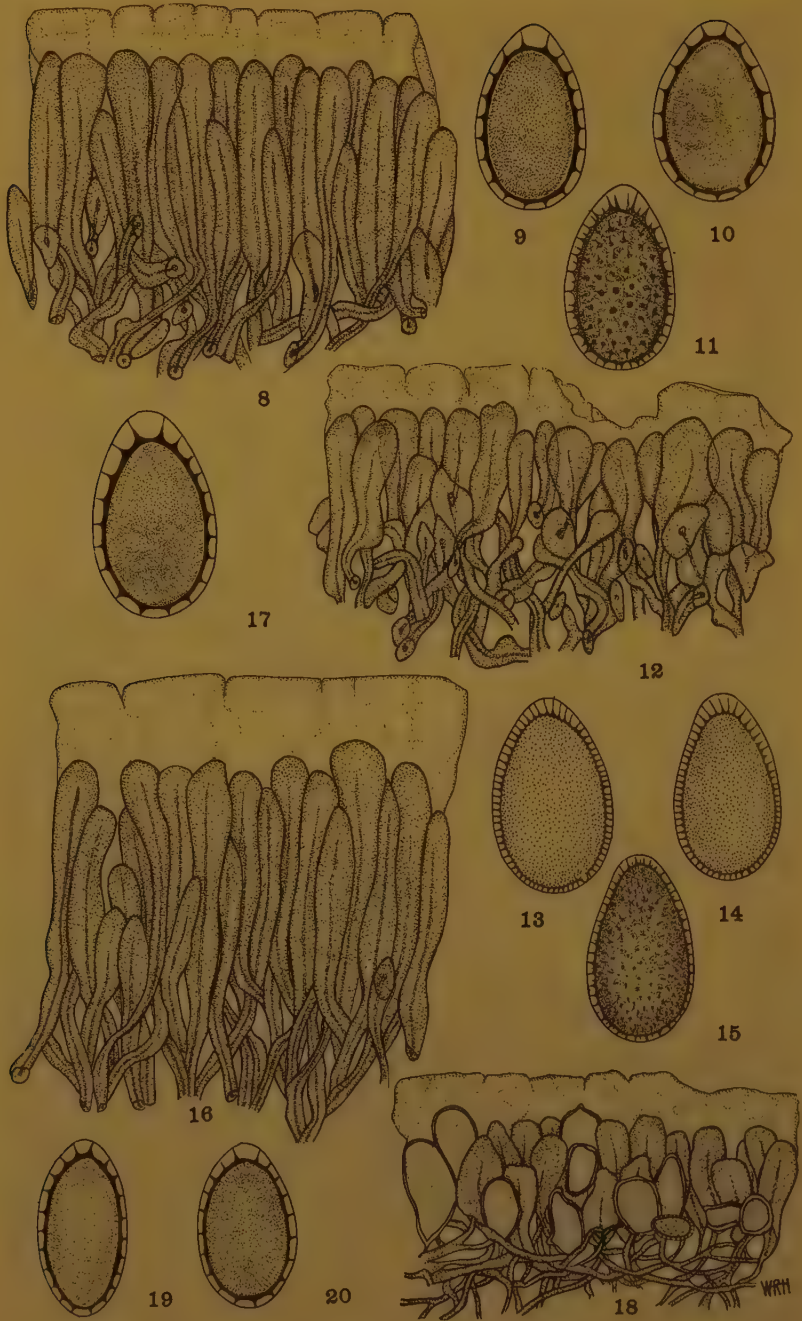
(a) *G. lucidum* (Leys.) Karst., a polypore found in Europe and America on hardwoods and conifers. It is especially common on Hemlock in America. The sporophore is distinguished by its heavy varnishing, and well developed "palisade" layer, its uniform context, and its thick-walled spores with coarsely echinulate endospore surface. *G. Tsugae* Murrill is a synonym.

(b) *G. sessile* Murrill, a polypore found in North America and in Europe on hardwoods (rarely conifers?). It is distinguished by comparatively lightly varnished, distinctively colored and marked sporophores. The sporophore has a duplex context, a somewhat thinner and more irregular palisade layer than *G. lucidum*, and thin-walled spores with very finely echinulate endospore surface. *G. subperforatum* Atk. is a synonym.

(c) *G. Curtisii* Berk., a polypore reported only from the eastern half of the United States. The sporophore is distinguished by its exfoliating crust, its duplex and darkly colored context, and its



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spores of variable size, which are coarsely echinulate on the endospore surface.

(d) *G. oregonense* Murrill, a species found in western North America on conifers. The sporophore is distinguished by its dark color, its very heavily varnished surface and deep crustal layer, its thick soft uniform context, and its relatively large spores which have coarse echinulations on the endospore surface.

7. A list of the specimens studied is recorded, and also a record of measurements of the spores of most of the species described in the North American Flora.

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EXPLANATION OF FIGURES OF PLATES 29 AND 30

- Fig. 1. Photograph of the upper surface of a sporophore of *G. lucidum* (the Remi Lake specimen, on Spruce. Herb. J. H. Faull, spec. 9718); $\times .3$.
- Fig. 2. Photograph of a sporophore of *G. lucidum* showing three years' growth and that of the current fourth. (Herb. J. H. Faull, spec. 185); $\times .5$.
- Fig. 3. Photograph of sporophore of Fig. 1 in vertical section; $\times .5$.
- Fig. 4. Photograph of sporophore of *G. sessile* in vertical section (Herb. J. H. Faull, spec. 180); $\times .5$.
- Fig. 5. Photograph of same sporophore, upper surface view; $\times .5$.
- Fig. 6. Photograph of sporophores of *G. Curtisii* (Herb. J. H. Faull, spec. 3568); $\times .4$.
- Fig. 7. Photograph of sporophore of *G. oregonense* (Herb. J. H. Faull, spec. 9355); $\times .3$.
- Fig. 8. Vertical section through crust of *G. lucidum* (Herb. J. H. Faull, spec. 9718); $\times 550$.
- Fig. 9. Sectional view of a spore of *G. lucidum*; $\times 1575$.
- Fig. 10. Sectional view of a spore of *G. lucidum*. This spore is rather larger than the average; $\times 1575$.
- Fig. 11. Surface view of a spore of *G. lucidum*; $\times 1575$.
- Fig. 12. Vertical section through crust of *G. sessile* (Herb. J. H. Faull, spec. 180); $\times 550$.
- Fig. 13. Sectional view of a spore of *G. sessile*. This spore is rather larger than the average; $\times 1575$.
- Fig. 14. Sectional view of a spore of *G. sessile*; $\times 1575$.
- Fig. 15. Surface view of a spore of *G. sessile*; $\times 1575$.
- Fig. 16. Vertical section through crust of *G. oregonense* (Herb. J. H. Faull, spec. 9355); $\times 550$.
- Fig. 17. Sectional view of spore of *G. oregonense*; $\times 1575$.
- Fig. 18. Sectional view through crust of *G. Curtisii* (Herb. J. H. Faull, spec. 3604); $\times 550$.
- Fig. 19. Sectional view of spore of *G. Curtisii*; $\times 1575$.
- Fig. 20. Sectional view of spore of *G. Curtisii*; $\times 1575$.

BIBLIOGRAPHY

1. AMES, ADELINE. A consideration of structure in relation to genera of the Polyporaceae. (Ann. Myc. 11: 3. 211-253. 1913.)
2. ATKINSON, G. F. Observations on *Polyporus lucidus* Leys. and some of its allies from Europe and North America. (Bot. Gaz. 46: 321-338. 1908.)

3. BOSE, S. R. Artificial culture of *Ganoderma lucidus* Leys. from spore to spore. (Bot. Gaz. 87: 665-667. 1929.)
4. COLEMAN, L. C. Structure of spore wall in *Ganoderma*. (Bot. Gaz. 83: 1-48. 1927.)
5. EDGERTON, C. W. The rate and period of growth of *Polyporus lucidus*. (Bull. Torr. Bot. Club, 7: 89. 1907.)
6. FRIES, E. *Systema Mycologicum*, vol. 1. 1821.
7. GARDNER & ETTINGHAUSEN. *British Eocene Flora*. 1884.
8. KARSTEN, P. A. *Myc. Fenn. Pars tertia. Basidiomycetes*. (Bidrag till kännedom af Finlands natur och folk. 25: 254. 1876.)
9. ———. *Enumeratio Boletinearum et Polyporearum Fennicum systemati novo dispositorum*. (Rev. Myc. 3: 9. 17. 1881.)
10. ———. Kritisk Öfversigt af Finlands Basidsvampar. (Bidrag till kännedom af Finlands natur och folk. 48: 327. 1889.)
11. MURRILL, W. A. The *Polyporaceae* of North America. (Bull. Torr. Bot. Club, 29: 601. 1902.)
12. ———. *North American Flora*, 9: 2. 118-123. 1908.
13. ———. *Northern Polypores*. 1914.
14. OVERHOLTS, L. O. The *Polyporaceae* of Ohio. (Ann. Missouri Bot. Gard. 1: 81-155. 1914.)
15. ———. Comparative studies in the *Polyporaceae*. (Ann. Missouri Bot. Gard. 7: 667-730. 1915.)
16. ———. The *Polyporaceae* of the Middle-western United States, 3: 44-46. 1915.
17. PATOUILLARD, N. Le genre *Ganoderma*. (Bull. Soc. Myc. France, 5: 64. 1889.)
18. QUÉLET, L. *Enchiridion fungorum in Europa media et praesertim in Gallia vigentium*. 1886.
19. SACCARDO, P. A. *Sylloge fungorum*, 6: 157 (1888).
20. SAPORTA, MARQUIS DE. *Origine paléontologique des arbres cultivés ou utilisés par l'homme*. 1888.
21. WHITE, J. H. On the biology of *Fomes applanatus*. (Trans. Roy. Can. Inst. 12: 133-174. 1919.)

PTERIDOPHYTES COLLECTED FOR THE ARNOLD
ARBORETUM ON VANIKORO, SANTA CRUZ
ISLANDS, BY S. F. KAJEWSKI

E. B. COPELAND

IN 1928 while collecting for the Arnold Arboretum in the New Hebrides Mr. S. F. Kajewski paid a visit to the Santa Cruz Islands and collected on Vanikoro Island from October 17 to December 15 188 numbers of plants of which 32 were Pteridophytes. Descriptions of the new species and notes on species already known follow. A list of all the species of Pteridophytes collected will be published later with the general enumeration of the Vanikoro plants.

Cyathea Veitchii (Baker), comb. nova.

Alsophila Veitchii Baker, Syn. Fil. ed. II. 41 (1873).

SANTA CRUZ ISLANDS: Vanikoro, common in rain-forest, alt. 50 m., no. 545, Oct. 28, 1928 (trunk up to 15 m. tall; fronds three to four meters long).

Baker's description is very brief, but fits this fern as far as it goes. It is clearly one of the group of *C. lunularis*, the type-group of *Alsophila*. Costae and costules are rather densely squamulose beneath; pinnules conspicuously caudate; sori small and very numerous.

***Tectaria grandifolia* (Presl) Copeland** in Philip. Jour. Sci. Bot. II. 413 (1907).

SANTA CRUZ ISLANDS: Vanikoro, rain-forest, no. 507, Oct. 18, 1928 (Fern with large fronds up to 1.5 m. high; sterile fronds much smaller, about $\frac{3}{4}$ m. high).

A species of uncertain status, based on a Cuming collection which was probably a mixture; apparently intermediate between *T. crenata* and *T. decurrens*. The rachis and the upper end of the stipe may be broadly winged, or the lower pinnae may be free. Described from the Philippines, and not positively known elsewhere.

***Oleandra angusta*, sp. nova.**

Rhizomate scandente, paleis appressis lanceolatis castaneis pallide marginatis ciliatis vestito, 3 mm. crasso; pedicellis 2 mm. longis, approximatis non verticillatis, paleis similibus minoribus vestitis; stipitibus 2 cm. longis, gracilibus; fronde 25–30 cm. longa, 10–14 mm. lata, utrinque longe attenuata, subcoriacea, costa paleis angustis 1 mm. longis horizontaliter distantibus ornata, lamina inferiore pilis nonnullis deciduis adpersa, aliter glabra, non ciliata et vix marginata; venis furcatis, tenuibus, arcte approximatis; soris 1.5–3 mm. a costa remotis, parvis, indusio nudo, firmo, oblique acroscopice aperto.

SANTA CRUZ ISLANDS: Vanikoro, rain-forest, alt. 50 m., no. 537, Oct. 25, 1928 (a branching fern found on giant Kauris).

A species well distinguished by its long, slender fronds with attenuate base, long stipe and short pedicel, paleate costa, and remote lines of sori. The veins are very fine and close; as they reach the margin, they are spaced about twenty to the centimeter.

***Lindsaya Kajewskii*, sp. nova.**

L. Lapeyrousii affinis, pinnis acroscopice bipinnatifidis distincta; rhizomate terrestri, brevirepente, intricato; stipitibus subcaespitosis, 2–3 cm. longis; fronde usque ad 30 cm. longa, media longitudine 4–5 cm. lata, utrinque angustata; pinnis medialibus 2.5 cm. longis, 1 cm. latis, basiscopice usque ad alam angustissimam costae excisis, recurvis, acroscopice in pinnulas ca. 4 unilateraliter subpinnatas et ca. 2 simplices ad alam aequi-angustam pinnatis; segmentis pinnulae quaeque majoris ca. 3, lineari-cuneiformibus; vena

in segmento quoque aut simplice aut furcato; soro solitario, infra-apicale.

SANTA CRUZ ISLANDS: Vanikoro, common in rain-forest, alt. 50 m. no. 523, Oct. 20, 1928 (growing on large rain-forest trees).

This species and *L. Lapeyrousii* constitute a group, of which *L. Blumeana* may be a representative with pinnate rachises, the affinity of the group as a whole being to that of *L. decomposita*, all anastomosis of veins of course disappearing with the fine dissection of the frond. *L. hymenophylloides* is not a member of this group; it and *L. fissa* are correspondingly finely cut relatives of *L. macraeana*.

***Lycopodium Kajewskii*, sp. nova.**

Phlegmaria, caulibus pendentibus usque ad 75 cm. longis, repetiter dichotomis, foliis inclusis 15–18 mm. crassis; foliis confertissimis, patentibus, subcoriaceis, 7–8 mm. longis, basi 2 mm. latis, acuminatis; spicis plerisque simplicibus, usque ad 10 cm. longis, 1.2–1.5 mm. crassis, sporophyllis deltoideis sporangiis aut aequantibus aut paullo longioribus.

SANTA CRUZ ISLANDS: Vanikoro, rain-forest, alt. 100 m., no. 573 (type), Nov. 6, 1928 (a common parasite on rain forest trees); same locality, alt. 50 m., no. 520, Oct. 20, 1928 (common, growing on large forest trees); same locality, alt. 100 m., no. 624, Nov. 12, 1928 (a parasitic plant, common on the great Kauri).

Well marked in its group by the small and exceedingly numerous leaves, and slender spikes.

Herter in Beiblatt zu den botanischen Jahrbüchern, nr. 98, p. 22, (1909), has reported *L. Phlegmaria* and *L. phlegmarioides* from Vanikoro; also *L. serratum*, *L. phyllanthum* and *L. oceanianum* from the New Hebrides. Kajewski has collected what I suppose is *L. oceanianum* on Efate island. From Vanikoro, he sends 9 sheets,—3 of *L. Kajewskii*, 2 of *L. Phlegmaria*, and one each of *L. cernuum*, a related species (sterile), *L. vanikorense*, and *L. nummulariifolium*.

***Lycopodium vanikorense*, sp. nova.**

L. setaceo affine gracilius, de arboribus pendente, caulibus repetiter dichotomis, deorsum foliis inclusis 5 mm. crassis; foliis subappressis, rectis, 8 mm. longis, vix 1 mm. latis, acutis, plerisque trifariis, saepe angustissime pallide-marginatis, sursum decrescentibus et fertilibus, ramis fertilibus 3–4 mm. crassis foliis 5 mm. longis.

SANTA CRUZ ISLANDS: Vanikoro, rain-forest, common, alt. 50 m., no. 521, Oct. 20, 1928 (found growing on large rain forest trees).

Distinguished from *L. bolanicum* by less spreading leaves and

consequently more slender shoots, and particularly by the more slender apices; from *L. Parksii* by the straight (not inflexed) and less acuminate leaves. *L. proliferum* Blume, ascribed by Herter to this group and by Baker to that of *L. squarrosus*, is unknown to me.

A SYNOPSIS OF ROBINSONELLA

EVA M. FLING ROUSH

With seven text figures

A SYNOPTICAL treatment of this group was thought advisable because of the difficulty of specific determination due to the scattered literature, the inadequacy of the original descriptions, the lack of a key to the species, the extreme variation in the form of leaf, the degree of pubescence and the small number or fragmentary nature of the specimens upon which some of the species were founded.

Robinsonella, a genus of tree mallows of the American tropics, named in honor of Dr. B. L. Robinson of the Gray Herbarium of Harvard, was established by Rose and Baker in 1897 with three species of which two, *R. cordata*, type of the genus, and *R. divergens*, were new, the third, *R. Lindeniana*, having formerly been referred to *Sida* and *Abutilon*. Only seven species are known at present and all are worthy of cultivation because of their showy flowers; they are, however, suited for subtropical and tropical regions only.

The author is indebted to those in charge of the following herbaria for the privilege of examining their material: the Arnold Arboretum and the Gray Herbarium of Harvard University, the New York Botanical Garden, the United States National Herbarium, the Missouri Botanical Garden and the Field Museum of Natural History.¹ Appreciation is due Mr. Alfred Rehder of the Arnold Arboretum for assistance and suggestions in the preparation of this paper.

Robinsonella Rose & Baker in Gard. & For. x. 244 (1897).—K. Schumann in Engler & Prantl, Nat. Pflanzenfam. Nachtr. II. 42 (1900).—Standley in Contrib. U. S. Nat. Herb. xxiii. pt. 3, 760 (Trees & Shrubs Mex.) (1923).

Shrubs or small trees up to 9 m. high, much branched, the younger and more herbaceous parts more or less stellate-pubescent (rarely pilose). Leaves alternate, petiolate, mostly ovate or orbicular in

¹AA, Arnold Arboretum; F, Field Museum of Natural History; G, Gray Herbarium of Harvard University; M, Missouri Botanical Garden; NY, New York Botanical Garden; US, United States National Herbarium.

outline, palmately 5-7-veined, up to 25 cm. long, cordate, subcordate or rounded at base, acute, acuminate or obtuse at apex, entire, dentate or more or less lobed; the lobes vary much in shape, size, number and dentation; petioles vary in length and pubescence; stipules if present, caducous. Flowers large, showy, in ample panicles or in small clusters on short lateral branchlets; bracts small, lance-linear; pedicels articulated near the middle or toward the apex, pubescent or puberulous; calyx cup-shaped, ebracteolate, deeply 5-parted, open or reflexed in fruit, externally densely stellate-pubescent or tomentose (rarely pilose), on the inner upper part arachnoid-pilose in the young stage; nectaries if present forming a pubescent 5-angled ring at the base of the calyx within; petals obovate, unguiculate, with a tuft of hairs on each side of the claw forming the so-called "weel," rarely pubescent dorsally toward the base; staminal column conic, varying in length with the size of the flower, glabrous or stellate-pubescent, dividing into numerous filaments; cells of the ovary 9-13, uni-ovulate; the ovule pendulous, becoming apparently basal by the rapid growth and inflation of the upper portion of the ovary; style-branches as many as the cells of the ovary, exceeding the stamens; stigmas capitate, papillose. Carpels 9-13, compact or spreading, obtuse at apex, thin, membranous, slightly veined, much inflated at maturity, perhaps tardily dehiscent from the base up along the back, the seed often hanging by a slender thread which runs dorsally along the full length of the carpel; seed very small, dark, glabrous or sparsely stellate-scurfy.

TYPE SPECIES: *R. cordata* Rose & Baker in Gard. & For. x. 244 (1897).

DISTRIBUTION: From the State of Durango in Mexico south to Costa Rica in Central America.

Robinsonella belongs in the tribe Malveae because the carpels are of the same number as the style-branches and the staminal column is antheriferous at the summit; to the subtribe Sidinae because of the capitate stigmas. It is most closely related to *Sida* and *Gaya* by the uni-ovulate cells of the ovary in which the seed is pendulous. It is distinguished from *Sida* by the more tree-like habit, by the thin, membranous, non-reticulated and much inflated carpels which are obtuse (erostate) and more or less divergent and separable, by the seed which occupies only a small space in the base of the carpel, by the sepals being smaller than the petals and open or reflexed at maturity. The species of *Gaya*, on the other hand, are herbaceous or suffruticose with undivided leaves, and chiefly yellow, sometimes purplish flowers which are pedunculate and solitary in the axils, often racemose; the apices of the mature carpels are

connivent, but separate from the persistent axis and are dorsally dehiscent into two valves at maturity.

KEY TO THE SPECIES

Inflorescence cymose-paniculate, terminal or axillary; leaves more or less lobed.

Leaves 3-5-lobed.

Leaves deeply 3- or 5-lobed, lobes ovate-oblong, constricted at base.....1. *R. Lindeniana*

Leaves more or less 3-lobed, lobes blunt or obtuse.....2. *R. divergens*

Leaves only slightly and irregularly lobed, often unequally-sided

3. *R. edentula*

Inflorescence not paniculate, flowers solitary or in 2's or 3's on short lateral branchlets; leaves obscurely or not at all lobed.

Leaves discolorous, with a fine, dense, appressed silvery tomentum beneath, more or less coarsely dentate.....4. *R. discolor*

Leaves green on both sides.

Leaves furfuraceous-tomentose beneath, ferrugineous on the veins, shortly acuminate.....5. *R. subcordata*

Leaves loosely stellate-pubescent beneath.

Leaves pilose on the veins and petioles.....6. *R. cordata*

Leaves not pilose on the veins or petioles, glabrescent.

7. *R. pilosa*

1. **Robinsonella Lindeniana** (Turcz.) Rose & Baker in Gard. & For. x. 245 (1897).—Standley in Contrib. U. S. Nat. Herb. xxiii. pt. 3, 760 (Trees & Shrubs Mex.) (1923).—Fig. 1.

Sida Lindeniana Turczaninow in Bull. Soc. Nat. Moscou, xxxi. pt. 1, 200 (1858).—Hemsley, Diag. Pl. Nov. ii. 24 (July 1879); Biol. Cent. Am. i. t. 9, 105 (Nov. 1879).—Gray in Proc. Am. Acad. Arts Sci. xxiii. 295 (1888).—Baker in Jour. Bot. xxx. 139 (1892); Syn. Malveae, 53 (1894).

Sida Ghisbreghtiana Turczaninow in Bull. Soc. Nat. Moscou, xxxi. pt. 1, 200 (1858).

Abutilon ? ambiguum Turczaninow in Bull. Soc. Nat. Moscou, xxxi. pt. 1, 205 (1858).

Shrub 2.5-3 m. high or larger, branchlets stellate-pubescent, often furfuraceous. Leaves large, up to 27 cm. long, dark green, sparsely stellate-pubescent or scabrous above, paler, densely and softly stellate-pubescent beneath; lower leaves deeply 5-lobed, the uppermost usually 3-lobed, the lobes ovate-oblong, constricted at the base, acute or shortly acuminate, entire or dentate; petiole up to 15 cm. long, stellate-pubescent, often furfuraceous or merely puberulous. Flowers in ample; open cymose panicles up to 3 dm. long and 2-3 dm. broad, branches and pedicels slender, usually furfuraceous-pubescent or puberulous; pedicels 2-4 cm. long, articulated a little below the flower; sepals broadly ovate-oblong, acute or slightly obtuse, pubescent or puberulous, nectaries present; petals white, 1-1.4 cm. long; staminal column short (4 mm.), conic, glabrous. Carpels 11-13, small, compact, about 1 cm. long, coarsely stellate-pubescent.

MEXICO. Vera Cruz: Orizaba, *M. Botteri*, no. 1134 (G, US); Barranca of Metlac near Orizaba, alt. 900 m., *C. G. Pringle*, no. 5906, Jan. 29, 1895 (G, US); Mirador, Orizaba, *F. M. Liebmann*, no. 430, March 1842 (AA, NY, US); Valley of Cordova, *M. Bourgeau*, no. 1501, Dec. 15, 1867 (G, US); Cordova, *J. M. Greenman*, no. 166, Jan. 25, 1906 (F); Canton de Huatusco, alt. 1200 m., *C. Conzatti*, no. 833, Dec. 1898 (G, US); Barranca de Tenampa, Zacuapan and vicinity, *C. A. Purpus*, no. 2210, Nov. 1906 (F, G, M, NY, US).



FIG. 1. *ROBINSONELLA LINDENIANA* (Turcz.) Rose & Baker.—Typical leaf, and smaller leaves from the upper part of flowering branches ($\times \frac{1}{2}$).

Robinsonella Lindeniana was first described by Turczaninow in 1858 in the same paper as three different species, the two flowering specimens were referred to *Sida* and the fruiting one questionably to *Abutilon*. This species resembles *Sida* only in the solitary pendulous seed in each carpel. Superficially the fruits resemble those of *Abutilon*, section *Gayoides* A. Gray (*S. crispum* Sweet), but differ in being uni-ovulate. Dr. Asa Gray created a separate section for this species in *Sida* and called it *Abutilastrum*. E. G.

Baker retained this section in his Synopsis Malveae and added other species of *Sida*. Later Rose and Baker removed this species from *Sida* and placed it in their new genus *Robinsonella*, which they had established upon *R. cordata*.

Robinsonella Lindeniana may be confused with *R. divergens*, but it has larger palmately 5-parted lower leaves with ovate-oblong constricted lobes, and slenderer and less furfuraceous branches and pedicels in the inflorescence. The sepals of *R. Lindeniana* are ovate-oblong and not reflexed in fruit.

2. *Robinsonella divergens* Rose & Baker in Gard. & For. x. 245 fig. 32 (1897).—Standley in Jour. Arnold Arb. xi. 34 (1930).—Fig. 2.

Small tree up to to 6 m. high, branchlets with coarse, furfuraceous stellate pubescence (rarely more or less puberulous). Leaves orbicular, cordate, up to 15 cm. long, slightly scabrous above, with dense short stellate pubescence beneath; the lower leaves 3-lobed,



FIG. 2. *ROBINSONELLA DIVERGENS* Rose & Baker.—Typical leaf, and small leaf from upper part of flowering branches ($\times \frac{1}{2}$).

the lobes acute or obtuse (in extreme forms very large, ovate-oblong, constricted at the base), entire or dentate; the uppermost leaves lanceolate, petioles up to 10 cm. long, coarsely stellate-pubescent (often furfuraceous). Flowers in large cymose-panicles up to 4 dm. long, branches and pedicels stout (if slender more or

less puberulous) covered with a furfuraceous stellate pubescence; pedicels up to 2 cm. long, articulated just below the flower; sepals lanceolate, acute, reflexed in fruit, stellate-pubescent, nectaries prominent; petals white, rarely striped with reddish purple, 0.5–1.5 cm. long; staminal column short (4 mm.), very slender, conic, glabrous. Carpels 9–10, large, spreading and widely separated at apex, strikingly stellate-pubescent or merely puberulous.

CENTRAL AMERICA. Guatemala: Santa Rosa, Dept. of Santa Rosa, alt. 900 m., *Heyde & Lux*, no. 4326, Jan. 1893 (F, G, NY); Cuajiniquilapa, Dept. of Santa Rosa, alt. 750 m., *Heyde & Lux*, no. 6299, Nov. 1893 (F, G). Honduras: vicinity of Siguatepeque, Dept. of Comayagua, alt. 1080–1400 m., *P. C. Standley*, no. 55975, Feb. 14–27, 1928 (AA, F, US); El Salvador: Santa Tecla, *S. Calderon*, no. 1515, March 1923 (G); vicinity of Santa Tecla, Dept. de La Libertad in Cafetal, alt. 790–950 m., *P. C. Standley*, no. 23021, April 10, 1922 (F, G, NY). Nicaragua: between Jinotega and Pantasma, *A. S. Oersted*, Jan. 1848 (F). Costa Rica: environs de San José, alt. 1200 m., *H. Pittier*, no. 2186, Dec. 1902 (US); San José, bords du rio Torres près San Francisco de Guadalupe, alt. 1135 m., *H. Pittier* (also *Ad. Tonduz*), no. 8471, Dec. 1892–93 (F, US; *syntype*); San José, bord d'un ruisseau, *Ad. Tonduz*, no. 1425, Nov. 28, 1880 (US; *syntype*); San José, alt. 1135 m., *Ad. Tonduz*, no. 7311, Jan. 1893 (F, G, US; *syntype*); San José, alt. 1080 m., *J. D. Smith*, no. 4751, April 1894 (G); vicinity of La Verbena, Prov. of San José, alt. about 1200 m., *P. C. Standley*, no. 32216, Jan. 29, 1924 (F); foothills south of San José, *J. M. & M. T. Greenman*, no. 5500, Feb. 8, 1922 (M); vicinity of San José, alt. about 1130 m., *P. C. Standley*, no. 47333, Dec. 4, 1925–Feb. 10, 1926 (F); mole de San Rafael (plaine du San Carlos), *H. Pittier*, no. 2600, June 1890 (US; *syntype*); environs of San Rafael, *Ad. Tonduz*, no. 1977, Feb. 13, 1890 (US; *syntype*).

Honduran forms of *Robinsonella divergens* resemble *R. Lindeniana* in having very large leaves with ovate-oblong lobes, more open panicles, more slender and less furfuraceous-pubescent branches and pedicels of the inflorescence, but the always three-lobed leaves, lanceolate and reflexed sepals and the larger, more widely separated carpels place them specifically with *R. divergens*.

3. *Robinsonella edentula* Rose & J. Donnell Smith in Bot. Gaz. xxxvii. 417 (1904).—Rose in Contrib. U. S. Nat. Herb. viii. 519 (1905).—Fig. 3.

Shrub or small tree, branchlets stellate-pubescent. Leaves sub-orbicular in outline, 3–9 cm. long, cordate at base with a deep

sinus, irregularly lobed and somewhat unequally-sided, shortly and sparsely stellate-pubescent above, densely and coarsely pubescent beneath, the lobes acute, obtuse or rounded, entire, undulate or slightly dentate, petioles 0.5–3 cm. long, coarsely stellate-pubescent. Flowers very abundant, in short axillary panicles up to 8 cm. long, pedicels slender 8–16 mm. long, stellate-pubescent, articulated near the apex; bracts when present lance-linear; sepals ovate-



FIG. 3. *ROBINSONELLA EDENTULA* Rose & Donn. Sm.—Leaf ($\times \frac{1}{2}$).

lanceolate, acute, stellate-pubescent, nectaries present; petals violaceous (pale lilac), 1 cm. long; staminal column very short (6 mm.), slender, glabrous. Carpels about 10, small, delicately veined, sparsely pubescent.

CENTRAL AMERICA. Guatemala: Cobán, Dept. Alta Verapaz, alt. 1300 m., *H. von Tuerckheim* no. 665 (Donn. Smith, Pl. Guatem. etc., no. 8382), Nov. 1902 (F, G, NY, US; *holotype*).

4. *Robinsonella discolor* Rose & Baker in Contrib. U. S. Nat. Herb. v. 181 (1899).—Standley in Contrib. U. S. Nat. Herb. XXIII. pt. 3, 370 (Trees & Shrubs Mex.) (1923).—Fig. 4.

Slender tree 6–9 m. high, branchlets glabrous with yellowish-gray bark. Leaves broadly ovate, up to 12 cm. long, cordate or subcordate at base, often unequally-sided, entire, coarsely dentate or obscurely lobed toward the acute or acuminate apex, discolorous, green above, covered with a fine, densely appressed, silvery tomentum beneath, with a tuft of long soft hairs at the base of the main veins; petioles up to 10 cm. long, puberulous. Flowers borne toward the apex of short lateral branchlets, solitary or in pairs on puberulous pedicels about 2 cm. long, pedicels articulated near the middle; sepals ovate, acute, covered with a fine tomentum, nectaries not evident; petals white, 6–10 mm. long; staminal column short (5 mm.), conic, glabrous. Carpels about 12, more or less compact, minutely stellate-tomentose.

MEXICO. San Luis Potosi: Las Palmas, Limestone hills, alt. 90–120 m., *C. G. Pringle*, no. 5767 (F, G, US; *syntype*) and no. 8007 (AA, F, G, M, NY, US; *syntype*), April 27, 1894 and March 2, 1899.



FIG. 4. *ROBINSONELLA DISCOLOR* Rose & Baker.—Leaf ($\times \frac{1}{2}$).

5. *Robinsonella subcordata* Hochreutiner in Ann. Conserv. Jard. Bot. Genève, XXI. 449 (1920).—Standley in Contrib. U. S. Nat. Herb. XXIII. pt. 5, 1674 (Trees & Shrubs Mex.) (1926).—Fig. 5.

Tree, branchlets with ferrugineous and furfuraceous tomentum. Leaves thick, ovate, 2–2.7 cm. long (young?), subcordate or rotund at base, almost entire, shortly acuminate, slightly tomentose above,



FIG. 5. *ROBINSONELLA SUBCORDATA* Hochreut.—Leaf ($\times \frac{1}{2}$).

densely furfuraceous-tomentose beneath, more or less ferrugineous on the veins; petioles 0.5–1.5 cm. long, densely tomentose, more or less furfuraceous and ferrugineous. Flowers many, congested on short lateral branchlets, pedicels up to 3 cm. long, tomentose, articulated near the middle; sepals ovate, 8 mm. long, acute, prominently one-nerved, gray-tomentose; nectaries evident; petals

pale lilac [?], 2.5 cm. long; staminal column attenuate-conic (8 mm.), stellate-pubescent. Carpels about 13, appressed tomentose when young (mature carpels not seen).

MEXICO. Oaxaca: Jayacatlan, *H. H. Rusby*, without no. (NY, *holotype*).

6. *Robinsonella cordata* Rose & Baker in Gard & For. x. 244, fig. 31 (1897).—Hochreutiner in Ann. Conserv. Jard. Bot. Genève, xxi. 450 (1920).—Standley in Contrib. U. S. Nat. Herb. xxiii. pt. 3, 761 (Trees & Shrubs Mex.) (1923); pt. 5, 1674 (Trees & Shrubs Mex.) (1926).—Fig. 6.

Tree 4–9 m. high, much branched, branchlets pilose or glabrescent. Leaves up to 15 cm. long, cordate or subcordate at base, long acuminate, dentate or slightly lobed toward the apex, softly



FIG. 6. *ROBINSONELLA CORDATA* Rose & Baker.—Typical leaf, and small leaf from the upper part of flowering branches ($\times \frac{1}{2}$).

pilose or glabrescent above, loosely stellate-pubescent beneath, pilose on the veins, petioles up to 5 cm. long, pilose. Flowers in 2's or 3's on short lateral branchlets; pedicels 1.5–2.5 cm. long, mostly densely pilose or rarely short stellate-pubescent, articulated near the middle; sepals large, ovate-lanceolate, gray-tomentose, not conspicuously nerved, nectaries evident; petals pale lilac

(sometimes white), about 1.5–2.5 cm. long, stellate-pubescent externally near the base; staminal column 5–8 mm. long, minutely and densely stellate-tomentose. Carpels 12–13, distinct nearly to the base, stellate-pubescent or rarely pilose.

MEXICO. Durango: San Ramon, *Edw. Palmer*, no. 54, April 21–May 18, 1906 (G, M, NY, US). Oaxaca: Hacienda de Guadalupe, alt. 1600 m., *C. Conzatti*, no. 2322, Dec. 6, 1908 (F, G, M); Cerro San Felipe, alt. 2000–3000 m., *Gonzales & Conzatti*, no. 881, Aug. 7, 1898 (G, US); alt. 2100 m., *Gonzales & Conzatti*, no. 671, March 7, 1898 (G, US); Tamazulpam, alt. 2000–2135 m., *E. W. Nelson*, no. 1955, Nov. 16, 1894 (US; *syntype*); San Luis Tultitlanapa, Puebla near Oaxaca, *C. A. Purpus*, no. 3251, April–May 1908 (F, G, M, NY, US); Sierra de San Felipe, alt. 2300 m., *C. G. Pringle*, no. 6244, Dec. 11, 1895 (AA, G, F, NY, US; *syntype*) (distributed as *Malva subtriflora* or *Malvastrum subtriflorum*); S. J. del Estado, Rancho de Calderon, alt. 1830 m. *L. C. Smith*, no. 529, Feb. 11, 1895 (G, US); without definite locality: *F. M. Liebmann*, no. 1090, 1841–43 (US); Hacienda de Riego, Tehue (?), cultivated, *C. Patini*, no. 7204a, March 13, 1917 (US).

Considerable variation in this species is shown in the kind and degree of pubescence, dentation and acumination of the leaves, in the size and color of the petals, and in the shape of the sepals. The presence of pilose hairs on veins, petioles, pedicels, calyx and branchlets, with the absence of furfuraceous or ferrugineous pubescence anywhere, are the most distinctive characters which separate this species from *R. subcordata*.

7. *Robinsonella pilosa* Rose in Contrib. U. S. Nat. Herb. VIII. 320 (1905).—Fig. 7.

Shrub or small tree, branchlets grayish-yellow, glabrous. Leaves ovate, up to 10 cm. long, cordate at base, not lobed, glabrescent above, loosely stellate-pubescent beneath, petioles up to 5 cm. long,



FIG. 7. *ROBINSONELLA PILOSA* ROSE.—Leaf ($\times \frac{1}{2}$).

glabrescent. Flowers clustered on short lateral branchlets, pedicels pilose; sepals ovate, obtuse, long pilose in the bud. Carpels 13 (?) fairly long stellate-pubescent, obscurely pilose in the younger stage.

CENTRAL AMERICA. Honduras: Valle de Comayagua, entre Villa de Flores y Comayagua, alt. 690 m., G. Niederlein, Feb. 22, 1898 (US, *holotype*).

The material upon which this species was founded is so fragmentary that it is difficult to give its relationship except tentatively as being much closer to *R. cordata* than to *R. edentula* as given in the original description. The pedicels and young flower-buds are as pilose if not more so than in some specimens of *R. cordata*. There is, however, no indication of lobing and no pilose hairs on the fragments of the leaves. A detailed description is not possible from the material available.

NEW SPECIES, VARIETIES AND COMBINATIONS FROM THE HERBARIUM AND THE COLLECTIONS OF THE ARNOLD ARBORETUM¹

ALFRED REHDER

With a text figure

Taxus cuspidata Sieb. & Zucc. f. **Thayerae** Wilson in Horticulture, VIII. 424, fig. (1930).

A typo recedit praecipue habitu humili depresso ramis gracilibus fere horizontalibus vel patentibus apice ascendentibus.

Plants and specimens examined: plants received in 1924 from the Bayard Thayer estate and now growing in the Arnold Arboretum under no. 17653; herbarium specimens collected in fruit, October 14, 1930.

A very handsome form of the Japanese Yew of low wide-spreading habit with nearly horizontally spreading or somewhat ascending branches. It is much more graceful than the other dwarf forms of *T. cuspidata*, as f. *nana* Rehd. (var. *brevifolia* Hort.) with rather stiff irregularly arranged branches reaching ultimately a height of 2 m., and f. *densa* Rehd. which is a very low and dense cushion-like shrub.

This Yew was raised from seed of *T. cuspidata* by Mr. William Anderson, superintendent of the Bayard estate at Lancaster, Mass. and the largest plants are now about 1.25 m. high and 4 m. in diameter.

Populus cathayana, sp. nov.

Populus suaveolens Schneider in Sargent, Pl. Wilson. III. 18, 28 (1916), quoad specimina sinensia citata.—Rehder in Jour. Arnold Arb. IV. 133 (1923), pro parte; Man. Cult. Trees & Shrubs, 88 (1927), pro parte.—Henry in Gard. Chron. ser. 3, LIII. 198, fig. 88 (1913), quoad icon.; in Elwes & Henry, Trees Gr. Brit. & Irel. VII. 1841, t. 410, fig. 25 (1913), quoad icon.—Non Fischer.

¹ Continued from vol. XI. 168.

Populus szechuanica Schneider in Sargent, Pl. Wilson. III. 21 (1916), quoad specimina Wilsoniana citata, nos. 1413, 2165, 4346, 4348, 4361.
 ?*Populus balsamifera* var. *suaveolens* Burkill in Jour. Linn. Soc. XXVI. 536 (1899), pro parte.

?*Populus balsaminifera* (sic) Kanitz in Szechenyi, Keletasz. Utján. Tudom. Eret. II. 842 (Pl. Enum. 58) (1891); in Szechenyi, Wissenschaft. Ergeb. Reise Ostas. II. 732 (1898).

Arbor ad 30 m. alta, trunco circuitu ad 4 m., omnino glabra; ramuli teretes, hornotini maturi aurantiaci vel fusco-aurantiaci vel griseo-lutei, annotini et vetustiores griseo-lutei, turiones teretes vel leviter obtuse angulati; gemmae purpurascens elongatae, viscidae. Folia ramulorum fructiferorum ovata vel anguste ovata, 6–10 cm. longa et 3.5–7 cm. lata, papyracea, distincte acuminata, basi rotundata, rarius leviter subcordata, minora interdum latissime cuneata, satis dense crenato-serrulata denticulis adpressis incurvis glanduligeris, ima basi integra vel remote denticulata, supra laete vel intense viridia, subtus albescentia, nervis utrinque 5–7 curvatis ut costa supra leviter subtus magis elevatis, rete venulorum subtus conspicuo et prominulo supra minus conspicuo vel fere obsoleto; petioli subteretes, graciles, 2–6 cm. longi; folia turionum pleraque oblongo-ovata, 12–20 cm. longa et 5.5–10 cm. lata, vel interdum majora basi saepe subcordata, dense glandulosa-denticulata, petiolis 1.2–3 cm. longis. Amenta mascula 5–6 cm. longa, bracteolae fimbriatae, glabrae; stamina 30–35, antheris circiter 2 mm. longis lineari-oblongis quam filamenta longioribus; amenta feminea visa tantum 4–5 cm. longa (vel longiora?), glabra; bracteolae fimbriatae; pedicelli brevissimi circ. 0–5 mm. longi, apicem versus fere 0; perigonii discus patelliformis, basin ovarii tantum cingens, circiter 2.5 mm. diam., margine integro; ovarium glabrum, ovoideum, 2–3 mm. longum, stigmatibus 2–4 dilatatis breviter stipitatis coronatum; amenta fructifera 10–20 cm. longa, fructibus satis distantibus brevissime pedicellatis vel subsessilibus; capsula ovoidea, acuta, 7–9 mm. longa, valvis plerumque 3 vel 4, rarius 2, acuminatis apice recurvis.

CHINA. Sze chuan: Fei yueh ling, Ching chi hsien, alt. 2100–2750 ft., *E. H. Wilson*, no. 1432, May 1908 (tree 12 m. tall, girth 1.25 m.; fruiting; type); same locality, *E. H. Wilson*, no. 1431, Oct. 1908 (bark); near Mongkong ting, ascent of Hsao chin ho, alt. 2100–2500 m., *E. H. Wilson*, no. 2164, June 29, 1908 (tree 12–24 m. tall, girth 1.5–2.5 m.; fruiting); west of Kuan hsien, Pan lan shan, alt. 2500–3000 m., *E. H. Wilson*, no. 4348, Oct. 1910 (tree 21–24 m. tall; fruiting); same locality, *E. H. Wilson*, no. 4346, Oct. 1910 (tree 18–24 m. tall; vigorous shoots); northeast of Tachienlu, forests of Ta pao shan, alt. 1600–4200 m., *E. H. Wilson*, nos. 1413, 2165, July 3 and 6, 1908 (tree 15–30 m., girth 1.5–3.5 m.; fruiting branches and

bark); same locality, planted around temples, *E. H. Wilson*, Veitch Exp. no. 4529, July 1903 (tree 18–24 m.); Mupin, alt. 2400–2700 m., *E. H. Wilson*, no. 4361, Oct. 1910 (tree 15–18 m., tall, girth 2–2.5 m.; vigorous shoots); between Hui li chou and Pai koa wan, *C. Schneider*, no. 532, March 31, 1914 (tree 8 m. tall, girth 0.3 m.; staminate flowers). K a n s u : Ho lan shan Mountains, rocky slopes, alt. 1375–2400 m., *R. C. Ching*, no. 75 (Wulsin Exp.), May 10–25, 1923 (tree 10 m. high; pistillate flowers); near Ping fan in gorge, alt. 2350–2800 m., *R. C. Ching*, no. 482 (Wulsin Exp.), July 12–20, 1923 (tree to 24 m.). S h a n s i : Lin hsien, Nan yang shan, alt. 2000–3000 m., *Tchuang Kieh*, Hers. no. 2067, Sept. 11, 1922 (tree up to 2 m. in girth); Fang shan hsien, Nan yang shan, alt. 1500–2500 m., *J. Hers*, no. 2700, Sept. 22, 1923 (leafy branches and vigorous shoots); Wu chai hsien, To nan kow, alt. 2000–3000 m., *Tchuang Kieh*, Hers. no. 2021, Sept. 7, 1922 (tree up to 3 m. in girth; vigorous shoot); Great Wall pass, alt. 1400 m., *J. Hers*, no. 2608, July 27, 1923; Wu tai shan, 1600 m., *J. Hers*, no. 2641, July 31, 1923; Tung Tsa, alt. 1500–1800 m., *C. O. Lee*, Herb. Univ. Nanking nos. 5512, 5543, 6027, July 1924; Lin kor shan, *K. Ling*, Herb. Univ. Nanking no. 9301 (tree 15 m. tall). C h i l i : Jehol, *W. Purdom*, no. 2, in 1909; Nankow, *J. Hers*, no. 1597, Aug. 14, 1921 (vigorous shoot); Po hua shan, *J. Hers*, no. 1654 (shoot); Hsiao Wu tai shan, alt. 1500 m., *F. N. Meyer*, no. 1311, Aug. 23, 1913 (leafy branches and detached fruit); same locality, *J. Hers*, no. 1488, July 1921 (fruiting branches); Huai lai hsien, Liu shu chwang, alt. 800 m., *J. Hers*, nos. 2079, 2080, Oct. 3, 1922; Ta hung men, *J. Hers*, no. 2217, Oct. 10, 1922; Huai lai hsien, Yang kia ping, alt. 900 m., *J. Hers*, no. 2091, Oct. 4, 1922; Peking Plain, *C. S. Sargent*, Sept. 17, 1903 (small tree); Peking, *J. Hers*, no. 2476, April 8, 1923 (staminate flowers); Miao feng shan, hills west of Peking, Shantung Univ. Coll. no. 69, Sept. 29, 1921; same locality, alt. 1000 m., *J. Hers*, no. 2538, June 12, 1923.

SOUTHERN MONGOLIA: Mont. Muniula, *N. M. Przewalski*, in 1872.

MANCHURIA: Jala tun, in park, *P. H. Dorsett*, no. 3480, June 27, 1925; Harbin, *C. S. Sargent*, Aug. 16, 1903 (tree with smooth pale bark deeply furrowed near base).

KOREA: Ping yang, *J. G. Jack*, Sept. 18, 1905 (sterile).

For some time I have suspected that the Chinese Poplar referred by most authors to *P. suaveolens* Fisch. does not represent typical *P. suaveolens*, judging from the figure given by Pallas in his *Flora Rossica* of the Davurian *P. balsamifera* upon which Fischer based his *P. suaveolens*. When in Leningrad in 1928 I took the opportunity

to examine Fischer's type specimen which came from Herb. Pallas and probably served for Pallas' drawing. At the same time I looked over all the material of *P. suaveolens* in the herbaria of the Botanic Garden and of the Academy of Sciences and came to the conclusion, that the two plants are quite different and that typical *P. suaveolens* does not occur in China at all, but is restricted to the region north of the Mongolian desert, while the Chinese plant is a new species described above as *P. cathayana*. This species occurs throughout northern China and ranges from western Szechuan and Kansu to Chili and Manchuria and possibly to Korea, if Jack's specimen from Ping yang belong here which is somewhat doubtful. *Populus cathayana* is more closely related to *P. Simonii* Carr., *P. Purdomii* Rehd. and *P. szechuanica* Schneid. than to *P. suaveolens* Fisch. which is easily distinguished by its oval or elliptic to elliptic-oblong leaves, generally broadest about the middle, abruptly acuminate at the apex with a very short often twisted acumen, with often slightly impressed veinlets above and usually slightly pilose beneath near base, and by its shorter petioles 0.5–3 cm. long, generally not longer than $\frac{1}{4}$ the length of the blade, and often slightly pilose. *Populus Purdomii* differs in its larger leaves, with somewhat coarser and not appressed serration usually short-pilose chiefly on the veins beneath and in the 2-valved capsules. In the size and shape of its leaves *P. cathayana* holds about the middle between *P. Simonii* which occupies nearly the same range and *P. szechuanica* which is known only from Szechuan and seems of restricted distribution. The latter differs from *P. cathayana* chiefly in the much larger broadly ovate leaves measuring on fruiting branches 10–20 cm. in length and 8–15 cm. in width with broad rounded or subcordate base and in the sharply angled vegetative shoots, while *P. Simonii* differs in its smaller leaves, usually 4–8 cm. long and broadest near the middle with broadly cuneate base, in the shorter 1–2.5 cm. long petioles, in the more or less angled vegetative shoots with short-petioled usually obovate leaves and in the slenderer catkins with smaller mostly 2-valved fruit. Of the specimens cited above Wilson's nos. 1413 and 2165 and Ching's no. 482 resemble somewhat *P. szechuanica* to which these Wilson numbers had been referred by Schneider besides nos. 4346, 4348 and 4361. I now restrict *P. szechuanica* to Wilson's nos. 2163 (type), 1434 and 4355. Wilson's Veitch Exped. no. 4529, Schneider's no. 843 and Sargent's specimen from Harbin approach *P. Simonii*.

One of the reasons why this Chinese species has been confused by many recent authors with *P. suaveolens* Fisch., is probably the absence or scarcity of material of the true species in the herbaria

of western Europe and of America; also in the herbarium of this institution the true *P. suaveolens* was not represented until I brought several duplicates from Leningrad two years ago. To which species the specimens from Songaria and Turkestan referred by several authors to *P. suaveolens* belong, I am not prepared to say, as I have not studied the Poplars of those regions.

***Populus cathayana* var. *Schneideri*, var. nov.**

A typo recedit folii venis supra et subtus minute puberulis, petioles et ramulis gemmisque densius et minute puberulis, rhachi amenti fructiferi et capsulis breviter pilosis.—Folia ovata, 6–9 cm. longa et 4–6.5 cm. lata, basi rotundata, serraturis parvis adpressis interdum fera obsolete, supra opace flavo-viridia, venis et petiolis flavescentibus; amenta fructifera circiter 8 cm. longa.

CHINA. Y u n n a n : Yung ning, *C. Schneider*, no. 1611, June 20, 1914 (large tree, bark as in *P. tremula*).

In all its other characters except in the fine pubescence of the branchlets, winter-buds and veins of the leaves and in the pilose capsules this specimen agrees well with typical *P. cathayana* as represented by Wilson's nos. 1432, 2164 and 4348, but the leaves show not the slightest tendency toward a subcordate base and the serration is less distinct. It is the most southern specimen of *P. cathayana* I have seen, but though Yung ning is in Yunnan it is situated close to the Szechuan border.

Populus Simonii Carrière in Rev. Hort. 1867, p. 360—Wesmael in De Candolle, Prodr. xvi. pt. II. 330 (1868); in Mém. Soc. Sci. Hainaut, III. 247 (Monog. Peupliers, 67) (1869).—Maximowicz in Bull. Soc. Nat. Moscou, LIV. 52 (1879).—Kantiz in Szechenyi, Keletasz. Utján. Tudom. Eret. II. 841 (Pl. Enum. 58) (1891); in Szechenyi, Wissensch. Ergeb. Reise Ostas. II. 732 (1898).—Dippel, Handb. Laubholzk. II. 211, fig. 105 (1892).—Komarov in Act. Hort. Petrop. XXII. 746 (1904).—Schneider, Ill. Handb. Laubholzk. I. 16, fig. 6, o–q (1904); in Sargent, Pl. Wilson. III. 21 (1917).—Dode in Mém. Soc. Hist. Nat. Autun, XVIII. (Extr. Monog. Inéd. Populus, 58, t. 12, fig. 90) (1905).—Gombocz in Math. Termesz. Közl. xxx. 105 (Monog. Gen. Populi) (1908).—Henry in Elwes & Henry, Trees Gr. Brit. & Irel. VII. 1839, t. 410, fig. 28 (1913).—Rehder in Jour. Arnold Arb. IV. 134 (1923); Man. Cult. Trees & Shrubs, 88 (1927).—Handel-Mazzetti, Symb. Sin. VII. 58 (1930).

Populus suaveolens var. a. Maximowicz in Bull. Soc. Nat. Moscou, LIV. 51 (1879).

Populus Przewalskii Maximowicz in Mém. Biol. XI. 321 (1881); in Bull. Acad. St. Pétersb. XXVII. 540 (1882).—Gombocz in Math. Termesz.

Közl. xxx. 101 (Monog. Gen. Populi) (1908).—**Synon. nov.**

Populus laurifolia γ. *Simoni* Regel, Russ. Dendr. ed. 2, 152 (1883).

Populus balsamifera μ . *Simonii* Wesmael in Bull. Soc. Bot. Belg. xxvi. 378 (1887).—Burkill in Jour. Linn. Soc. xxvi. 536 (1899).

Populus balsamifera var. *laurifolia* Burkill, l. c. 535 (1899), pro parte.—Non Wesmael.

Populus balsamifera var. *suaveolens* Burkill in Jour. Linn. Soc. xxvi. 535 (1899).—Non Loudon.

Populus brevifolia Carrière ex Schneider, Ill. Handb. Laubholz I. 16 (1904), pro synon.

Populus suaveolens var. *a. angustifolia* Gombocz in Math. Termesz. K. z l. xxx. 110 (Monog. Gen. Populi) (1908); vix Regel.

Populus Przewalskii f. *microphylla* Gombocz in Math. Termesz. K. z l. xxx. 105 (Monog. Gen. Populi) (1908).

Populus suaveolens Schneider in Sargent, Pl. Wilson iii. 18 (1916) pro parte, quoad specimina citata, Tibet, Kansu, Chili et Wilson nos. 2162 and 4577 e Szechuan bor.—Rehder in Jour. Arnold Arb. iv. 135 (1923).—Non Fisch.

Populus suaveolens var. *Przewalskii* Schneider in Sargent, Pl. Wilson. iii. 32 (1916), specimine e Mongolia citato et descriptione exceptis.—Rehder in Jour. Arnold Arb. iv. 133 (1923).

EASTERN TIBET: K o k o n o r : *N. M. Przewalski*, 2/14 July 1880 (syntype in herb. Petrop.); ad fl. Tchurmyn, 9–9500 ft., *N. M. Przewalski*, 2/14 May (1880) (herb. Petrop.); Kuen-luen “nördliche Vorberge von Nanshan, Da-tschouan,” 5000 ft., *W. J. Roborowski*, May 10, 1894 (herb. Petrop.).

MONGOLIA. Alashan, Van-usin-uin, *S. S. Tchetyrkin*, no. 444, July 16, 1908 (herb. Petrop.); northern Mongolia, *E. Klementz*, in 189.?.; Ordos, Baga-gol, *G. N. Potanin*, Sept. 12, 1884 (herb. Petrop.); Ordos, *N. M. Przewalski*, Aug. 1871 (herb. Petrop.).

CHINA. K a n s u : ad Hoangho superiorem, *N. M. Przewalski*, 2/14 April 1880 (syntype in herb. Petrop.); without precise locality, *N. M. Przewalski*, 22 Aug./3 Sept. 1872 (syntype in herb. Petrop.); Shan-dan-siang, *P. J. Piasezki*, 22 July/4 Aug. 1875 (syntype in herb. Petrop.), Han-tschou-fu, *P. J. Piasezki* 17/29 July, 1875 (syntype in herb. Petrop.); without precise locality, *P. J. Piasezki*, 26 May/7 June 1875 (herb. Petrop.); oppidum Talachi, 26 Oct. 1884, *G. N. Potanin* (herb. Petrop.); ad fl. Bardun, *G. N. Potanin*, 18 May, 1884 (herb. Petrop.); Hoang-ho, *L. de Loczy*, no. 219, Aug. 1879 (herb. Budapest); Pin-fan, *S. S. Tchetyrkin*, no. 559, July 22, 1909; vicinity of Ningsia, alt. 1750–1850 m., *R. C. Ching*, no. 225, June 4–10, 1923; near Pingfan, alt. 2350–2800 m., *R. C. Ching*, no. 505, July 12/20, 1923; inter Kansu et Thianshan, ante Anssitschou, *P. J. Piasezki*, 8/20 Aug. 1875 (herb. Petrop.). S z e c h u a n : Min valley, Wen chuan hsien, 4–7000 ft., *E. H. Wilson*, no. 1420, Oct. 1908; Min Valley, Sungpan to Mao chow, alt. 2–3000 m., *E. H. Wilson*, no. 4577, Aug. 27, 1910; Monkong Ting, alt. 2400–3000 m., *E. H. Wilson*, no. 2162, June 28, 1908. Y u n n a n : ad fluv. Landsang-djiang (Mekong) near Wei-hsi, alt. 2300 m., *H. Handel-Mazzetti*, no. 10034, Sept. 17, 1916. H u p e h : Hing shan

hsien, alt. 4000 ft., *E. H. Wilson*, no. 1454, Aug. 5, 1907. **S h e n s i :** Yen-an-fu, *Wm. Purdom*, no. 351, in 1910; Lungshow, Kuan shan, alt. 2000 m., *J. Hers*, no. 2333, July 3, 1922; Lintung, alt. 350 m., *J. Hers*, no. 3018, Oct. 28, 1924; Tsing Ling, 60 km. south of Sianfu, alt. 1000–1500 m., *J. Hers*, no. 3015, Oct. 20, 1924. **S h a n s i :** in valle fl. Shaho, *G. N. Potanin*, June 3, 1884 (herb. Petrop.); Tai-yuan-fu plain, Fen ho valley, alt., 800 m., *J. Hers*, no. 2702, Oct. 4, 1923; Wu chai hsien, 2000–3000 m., *Tchuang Kieh*, *Hers* no. 2022, Sept. 7, 1922. **C h i l i :** Peking, *J. Hers*, nos. 2255, 2256, 2257 and 2259, Oct. 18, 1922; Peking, *W. Y. Hsia*, May 3, 1926; Peking, western hills, *J. Hers*, nos. 2219 and 2227, Oct. 11, 1922; Po hua shan, *J. Hers*, no. 1651, Sept. 9, 1921; near Sun tun ying, *F. N. Meyer*, nos. 974 and 975, May 31, 1913; Huai Lai hsien, Lin shu chwang and Yang kia ping, *J. Hers*, nos. 2073 and 2080, Oct. 3 and 4, 1922; Ta han ling, *J. Hers*, no. 1642, Sept. 7, 1921; Nankow, *J. G. Jack*, Oct. 6, 1905; Kalgar, Methodist compound, *N. H. Cowdry*, no. 1441, June 6, 1921. **H o n a n :** Neihwang, alt. 100 m., *J. Hers*, no. 2457, Oct. 31, 1922; Min chih, alt. 580 m., *J. Hers*, no. 2523. **K i a n g s u :** Yas wan (on the Great Canal), *J. Hers*, nos. 624 and 625, May 2, 1921; Nanking, *K. Ling*, no. 7946, May 1925, (tree 50 ft. high, in open places).

MANCHURIA: common north of Harbin, *C. S. Sargent*, Aug. 29, 1903; Harbin, *P. V. Suizev*, Aug. 1905 (herb. Petrop.); near Harbin, *B. Skvortsov*, July 1927.

KOREA. North He i a n p r o v. : Wijyu, *T. Nakai*, no. 1952, June 3, 1914; abundant on Yalu river around Shingishu, *E. H. Wilson*, no. 8784, July 16, 1917. South K a n k y o : Hensan to On-senri, *E. H. Wilson*, no. 9343, Oct. 5, 1917.

Populus Simonii and *P. Przewalski* have been regarded up to the present by all authors as two distinct species, but an examination of the type material in the herbarium of the Botanic Garden at Leningrad convinced me that there is no specific difference between the two. The very characteristic short-petioled, obovate leaves of vegetative shoots of *P. Simonii* are also present on vegetative branches of *Piasezki's* specimen from Kansu collected May 26/June 7, 1875, and the leaves of mature trees of the Kansu specimens are not different from those of specimens collected near Peking which is the region from which *P. Simonii* was introduced. Fruiting specimens from both regions agree in their slender catkins and small mostly two-valved fruits. Maximowicz knew *P. Simonii* only from the description (see Bull. Soc. Nat. Moscou, LIV. 52) and one can readily understand that he did not identify this species described as having strongly angled branches and short petioled leaves 14–18

cm. long with his material from mature trees which showed terete branches and slender-petioled small leaves. These differences which are really differences between young and mature plants were emphasized by later authors as Dode and Gombocz who probably had seen little if any typical material of *P. Przewalskii*, but were well acquainted with *P. Simonii*. Also Schneider when describing his *P. suaveolens* var. *Przewalskii* had seen no material of typical *P. Przewalskii* and based his description on Potanin's specimen from "circa lacus Ubsa" which he had received from Kew under the name *P. Przewalskii*, though it is not enumerated by Maximowicz. Potanin's specimen, however, which I saw in Leningrad, is entirely different from typical *P. Przewalskii* and belongs to *P. pilosa* Rehd., though the specimen is not so distinctly and densely pilose as the type from Baga Bogdo, Altai Mountains. Also *Populus suaveolens* var. *macrocarpa* Schrenk seems nearer to *P. pilosa* than to any other species, but its fruits are glabrous.

Populus Simonii has a wide distribution; it ranges from the Kokonor region of eastern Tibet through northern China and southern Mongolia to Manchuria and northern Korea. It is chiefly characterized by normally rather small leaves, those of mature trees generally rhombic-ovate, 4–8 cm. long, acuminate, broadly cuneate at the base and borne on slender petioles 1–2.5 cm. long; the leaves of vigorous vegetative shoots and young plants are rhombic-obovate to elliptic and usually 4–8 cm. long, abruptly short-acuminate, narrowed toward the base and borne on short petioles usually 0.5–1.5 cm. long, but occasionally the leaves may be up to 15 cm. long and the petioles correspondingly longer. The shoots are more or less angled, but the branches of mature trees are terete. The fruits are rather small and 2- or partly 3-valved; they are either pubescent as described by Maximowicz or glabrous as in Piasezki's specimen from Shan dan siang (syntype); also the only fruiting specimen I have seen from near Peking has glabrous fruit. It may be assumed therefore that typical *P. Simonii* has glabrous fruit. The form with pubescent fruit may be distinguished as f. **Przewalskii** (Maxim.), f. nov., with Przewalski's specimen from Kokonor as the type.

Populus Simonii is related to *P. suaveolens* Fisch. and *P. cathayana*. The former which is geographically well separated by the Mongolian desert, is easily distinguished by somewhat larger elliptic or elliptic-ovate to elliptic-oblong or occasionally elliptic-obovate leaves, abruptly short-acuminate at the apex and more or less rounded at the base and borne on petioles generally not longer than $\frac{1}{4}$ the length of the leaf; the branches are always terete. *Populus*

cathayana, whose range is similar, differs chiefly in the larger, distinctly ovate leaves broadest below the middle, more gradually acuminate at the apex and rounded or subcordate at the base, in the petioles being up to 6 cm. long and usually about $\frac{1}{2}$ as long as the blade, or even longer and in the always terete branches.

Two forms differing in habit have been introduced into cultivation: *P. Simonii* f. *pendula* Schneider (in Sargent, Pl. Wilson. III. 22, 1916) with pendulous strongly angled branches, and *P. Simonii* f. *fastigiata* Schneider (l. c.) with ascending slightly or scarcely angled branches forming a pyramidal head.

Populus suaveolens Fischer in Allg. Gartenzeit. ix. 404 (1841); in Bull. Acad. Sci. St. Pétersb. ix. 348 (1842).—Ledebour, Fl. Ross. III. 629 (1850).—Maximowicz in Bull. Soc. Nat. Moscou, LIV. 51 (1879), quoad var. b.—Koehne, Dendr. 84 (1893), pro parte.—Schneider, Ill. Handb. Laubholz. I. 14 (1904), pro parte.—Dode in Mém. Soc. Nat. Hist. Autun, XVIII. (Extr. Monog. Populus, 61) (1905), pro parte.—Ascherson & Graebner, Syn. Mitteleur. Fl. I. 48 (1908), pro parte.—Elwes & Henry, Trees Gr. Brit. & Irel. VII. 1841 (1913), pro parte et excl. icon.—Schneider in Sargent, Pl. Wilson. III. 18 (1916), pro parte.—Rehder, Man. Cult. Trees & Shrubs, 88 (1927), pro parte.

Populus balsamifera Pallas, Fl. Ross. I. pt. I, 67, t. 41 (1784), excl. fig. B.—Non Linnaeus.

Populus pseudo-balsamifera Turczaninow in Bull. Soc. Nat. Moscou, I. 101 (1838), nom. nudum; secundum specimen orig. in Herb. Petrop. *Populus balsamifera* var. 4. *intermedia* Loudon, Arb. Brit. III. 1674 (1838).

Populus balsamifera var. 5. *suaveolens* Loudon, l. c. (1838).—Wesmael in De Candolle, Prodr. XVI. pt. II. 330 (1868); in Mém. Soc. Sci. Hainaut, III. 246 (Monog. Peupliers, 66) (1869).—Dippel, Handb. Laubholz. II. 206, fig. 100 (1892).

Populus suaveolens var. β . *latifolia* Gombocz in Math. Termesz. Közl. XXX. 111 (Monog. Gen. Populi) (1908); vix Regel.

EASTERN SIBERIA. Gov. Irkutsk: V. Komarov, June 14, 1902 (herb. Petrop.); near Kirenga river, M. Tomin, Iter ad fl. Lena et Kirenga, no. 282, July 26, 1909; locality not identified, N. I. Kusnezov, no. 1364, July 25, 1910 (herb. Acad. Petrop.). Transbaikalia: "Dahuria" Hb. Pallas ex Herb. Fischer (Herb. Petrop.); ad ostium torrentis Utulik, N. S. Turczaninow, in 1835 (herb. Petrop.); Bargusina, I. F. Krynkov, nos. 189, 1608, July 30, 1905 (herb. Petrop.); Schilka river, C. Maximowicz, June 7, 1859 (herb. Petrop.); Nerchinsk, I. M. Krascheninnikov, nos. 1265, 1271, June 4 and 7, 1909 (herb. Petrop.); Zabaik, V. I. Syrjanov, nos. 3, 40, in 1908, I. W. Nowopokrowsky, in 1908, I. F. Krynkov, nos. 50, 54, June 15 and July 18, 1909, V. N. Lipsky, July 2, 1901, B. Fedt-

schenko, nos. 172, 294, in 1909, *E. F. Trofimova* & *V. E. Rudzinsky*, no. 411, in 1911, *Stukow*, Pl. Transbaical. (all in herb. Petrop.); locality not identified, *I. I. Yarygin*, no. 199, in 1908. Gov. Y a k u t s k : inter fl. Wilui (640 N. L.) et fl. Olenek (68° N. L.) *R. Maak*, in 1854 (herb. Acad. Petrop.); Burchan, Nitschatka, *G. Maydell*, June 20, 1872; localities not identified, *F. V. Sokolov*, nos. 181, 311 and 312 in 1909; "ad fl. Maja," *W. Drobow*, no. 499, July 21, 1912 (all in herb. Petrop.).

This species which by recent authors has been confused with the two Chinese Poplars discussed above from which it is well separated by morphological characters and removed geographically. It is the most northern of the Asiatic Poplars occurring as it does between 50° N. Long. and the Arctic Circle. According to the specimens seen it ranges from the former Gov. Irkutsk through Transbaicalia to the Gov. Yakutsk; farther east it is replaced by *P. Maximowiczii* Henry which is a closely related species and occurs in Kamtschatka, Saghalin, the Maritime Province, Mandschuria, Korea and Japan; it is chiefly distinguished by pubescent branchlets, larger leaves pubescent beneath, and pubescent petioles. There are, however, glabrescent forms and the two species are not always readily separated. Another closely related species *P. koreana* Rehd. occurs in northern Korea, and is chiefly distinguished by its viscid-glandular young shoots.

Populus suaveolens var. *β. pyramidalis* Regel, Russk. Dendr. 96 (1870); ed. 2, p. 151 (1883).

Forest Institute at Leningrad, planted, *E. Wolf*, without date and Sept. 1928.)

This form differs from the type in its ascending branches forming a pyramidal head. The leaves on mature branches are oval or elliptic-ovate, 6–7 cm. long and 4–5 cm. broad, rounded at base and abruptly acuminate, short-pilose on the midrib above and beneath and sparingly so on the veins; the petioles are 1.5–2 cm. long and pilose. The leaves of the perfectly terete vegetative shoots are ovate-oblong up to 10 cm. long, rounded at base or elliptic-oblong and short-petioled and glabrous on both sides. The tree is staminate and the catkins are 4 cm. long; bracteoles cuneate-obovate, deeply lacinate, strigose-pilose on the back and with ciliate lobes; anthers ellipsoid, 1–1.5 mm. long, on slender filaments longer than the anthers.

Corylus Fargesii Schneider, Ill. Handb. Laubholzk. II. 896, fig. 561 d (1912); in Sargent, Pl. Wilson. II. 444 (1916).

Corylus rostrata Ait. var. *Fargesii* Franchet in Jour. de Bot. XIII. 199 (1899).—H. Winkler in Engler, Pflanzenr. IV–61, p. 53, fig. 14 F (1904).

Corylus mandshurica Maxim. var. *Fargesii* Burkill in Jour. Linn. Soc. xxvi. 505 (1899).—Diels in Bot. Jahrb. xxix. 281 (1900).

CHINA. Szechuan: Tchen-keou-tin, *P. Farges*, no. 1307 (holotype); Sungpan hsien, woods, *W. P. Fang*, no. 4251, Aug. 17, 1928 (tree 10 m. high.)

An examination of the type specimen of *Corylus rostrata* var. *Fargesii* convinced me that the plant, as already pointed out by Schneider (in Pl. Wilson, l. c.), is not closely related to *C. rostrata* Ait. or *C. Sieboldiana* var. *mandschurica* (Maxim.) Schneid. but more nearly to *C. chinensis* and that it possibly might be considered a variety of the latter species, from which it differs chiefly in the oblong, thin, nearly glabrous leaves, rounded to truncate or even broadly cuneate at the unequal base. The fruit in its husk and nut agrees very well with that of *C. chinensis*, while in *C. rostrata* and in *C. Sieboldiana* and its varieties the husk is more gradually contracted above the nut which is ovoid, higher than broad and has a much smaller hilum and thinner walls. The staminate catkins are arranged 3–6 in a more or less elongated raceme and the bracts of the catkins are closely and finely pubescent with a glabrescent mucro, while in *C. rostrata* and in *C. Sieboldii* var. *mandschurica* the catkins are produced in sessile clusters of 2–3 or solitary and the bracts are rather densely hairy with a long-ciliate mucro. Also the serration of the leaves of *C. Fargesii* resembles more that of *C. chinensis* with shorter and blunter teeth than that of *C. Sieboldiana* which has longer acuminate teeth. The specimens collected by Fang near Sungpan agrees exactly with Franchet's type, but the fruits had induced me to consider it, before I had seen Franchet's type, an extreme form of *C. chinensis* with much narrower leaves.

Hydrangea Chungii, sp. nov. (§. EUHYDRANGAEA, ser. Petalanthae).

Frutex; rami hornotini fuscuscentes dense pilis strigoso-villosis brevibus et patentibus ad 3 mm. longis vestiti, annotini epidermide soluto glabri, albido-cinerei. Folia membranacea, elliptico-oblonga, 12–20 cm. longa et 4.5–8.5 cm. lata, acuminata, basi cuneata, imo basi excepto serrato-dentata dentibus leviter vel vix sursum curvatis, supra laete viridia, satis dense pilis brevibus et longis sub-accumbentibus conspersa, subtus pallidiora tota facie satis dense breviter villosa-pilosa et praesertim ad costam, nervos et venulas conspicue hirsuta pilis hyalinis ad 3 mm. longis, nervis utrinque 8–12 curvato-ascendentibus supra inconspicuis subtus leviter elevatis; petioli 1–4 cm. longi, hirsuti et breviter pubescentes. Cyma plana, floribus sterilibus exclusis 7–9 cm. diam., breviter pedunculata pedunculo 1–2.5 cm. longo pilis breviter et longioribus hirsutis vestita, floribus sterilibus paucis (4–7) praedita; flores steriles

quadriseptali, sepalis obovato-rotundatis in fructu 1.5–2.2 cm. longis utrinque pubescentibus integris, pedicello gracili pubescente sub fructu ad 3 cm. longo suffulta; flores fertiles (alabastra tantum visa) cyaneo-purpurascens, 5-meri; pedicelli 1–2 mm. longi ut calyx dense strigosi; calycis lobi triangulares, acuti, circiter 1 mm. longi; petala (non plane evoluta) elliptica, circ. 2 mm. longa; stamina 10; styli 3, rarius 2; ovarium semi-inferum sub anthesi tantum paullo e tubo calycis exsertum; capsula matura globosa-ovoidea, stylis erecto-patentibus exclusis circ. 2 mm. longa, ovario tubum calycis triente superans; semina ovoidea, exalata, 0.5 mm. longa.

CHINA. F u k i e n : Yenping, Fort north of Steps 3800, on slopes, alt. 230 m., *H. H. Chung*, Aug. 21, 1924 (type); Yenping, Buong Kang, in thickets, *H. H. Chung*, June 8, 1925.

This new species is apparently related to *H. Moellendorffii* Hance with which the specimens cited above have been confused. The latter species which is known only from the type specimen in the British Museum differs chiefly in the strigillose appressed pubescence of leaves and stem, the smaller shorter-petioled leaves, the smaller long- and slender-stalked inflorescence with few disepalous sterile flowers. The two species are apparently very local, *H. Moellendorffii* being known only from near Kiukiang, Kiangsi, and *H. Chungii* only from near Yenping, Fukien.

Liquidambar Styraciflua L. f. rotundiloba, forma nova.

A typo recedit foliis obtusilobatis lobis rotundatis plerumque latioribus quam longis remote et saepe indistincte serrulatis.

NORTH CAROLINA: near Pinehurst, *R. E. Wicker*, September 15, 1930.

This form differs so much in its leaves from typical Sweetgum that at the first glance one would hardly recognize it as belonging to *Liquidambar*. The leaves with their broad rounded indistinctly serrulate lobes usually broader than long, rarely somewhat longer than broad, resemble more those of a Maple, than those of Sweetgum which have acuminate sharply and rather closely serrulate lobes. The leaf variations so far known and discussed and figured by Theo. Holm¹ always show acuminate or acute lobes or on unlobed leaves an acute apex and occur either on seedlings and juvenile plants or on mature trees at the base or apex of the branchlets. They are thus of ontogenetic nature and not distinct forms of individual trees. The majority of leaves on mature trees show little variation and all the numerous specimens in this her-

¹ HOLM, THEO. Leaf-variations in *Liquidambar Styraciflua* L. (*Rhodora*, xxxii. 95–100, pl. 200, 201. 1930).

barium representing its whole range of distribution show uniformly leaves with triangular-ovate to triangular-oblong acuminate sharply serrulate lobes without any transitions to this new form with short and broad rounded lobes.



LIQUIDAMBAR STYRACIFLUA f. ROTUNDILOBA Rehd.—Leaves ($\times \frac{1}{2}$).

We owe the discovery of this interesting form to Mr. R. E. Wicker of Pinehurst, North Carolina, who kindly sent us branches from the single tree he found of this form. He states in his letter that he examined the whole tree and the shoots around it for reversion to the type, but found all the leaves uniformly of the shape described above; he also mentions that in bark and limb formation the tree differs somewhat from the typical form. He promised to send to this Arboretum branches for grafting, so that we may hope to have this interesting new form soon growing here.

Crataegus scabrifolia, comb. nov.

Pyrus scabrifolia Franchet, Pl. Delavay. 229 (1889).—Léveillé, Cat. Pl. Yun-Nan, 231 (1917).

Crataegus Henryi Dunn in Jour. Linn. Soc. xxxv. 494 (1903).—Schneider, Ill. Handb. Laubholz k. 1. 770, f. 435, 1-6 (1906).—Diels in Notes Bot. Gard. Edinb. vii. 236 (1912).—Sargent, Pl. Wilson, i. 181 (1913).—Léveillé, Cat. Pl. Yun-Nan, 229 (1917).—**Synon. nov.**

CHINA. Yunnan: Tali (an culta?) *J. M. Delavay*, no. 3731, June 1882 (type in herb. Paris); Tali range, alt. 8–10000 ft., *G. Forrest*, nos. 4430 and 4432, May and August 1906; Mengtze, 5000–5500 ft., *A. Henry*, nos. 9426, 9426a and 9426b (tree 10–20 ft., flowers white; type of *C. Henryi*); “commun dans les vallées et coteaux à Tong-tchouan, alt. 2550 m.,” *E. E. Maire*, Arnold Arb. nos. 455 and 456, about 1912 (“fl. blanches—fruits rouges utilisés pour les confitures”); Teng Yueh, versus flum. Salween, *C. Schneider*, no. 3183, Oct. 1914; openings in dense mixed and conifer forest on the hills between Sha-yang and Chu-tong, alt. 8–9000 ft., *G. Forrest*, no. 21143, April 1922 (shrub 20–30 ft.; flowers creamy white); watershed of the Black River or Papien ho between Mohei and Maokai (Mopo and Manpieh), *J. F. Rock*, no. 2927, March 21, 1922; without precise locality, *G. Forrest*, nos. 7668, 9853, 11831, 17922, 18585.

Having examined Franchet's type of *Pyrus scabrifolia* (labeled by Franchet *Pirus scabrida*) in the herbarium at Paris I find that the specimen is not a *Pyrus* of the section *Aria* as stated by Franchet, but that it is a *Crataegus* and without doubt identical with *C. Henryi* Dunn, a species apparently common in Yunnan. Franchet's specific name being the older has to replace Dunn's name.

***Pyracantha crenato-serrata*, comb. nov.**

Photinia crenato-serrata Hance in Jour. Bot. xviii. 261 (1880).—Hemsley in Jour. Bot. xxiii. 262 (1887).

Cotoneaster Pyracantha Pritzel in Bot. Jahrb. xxix. 386 (1900), in part.—Pampanini in Giorn. Nuov. Bot. xvii. 288 (1910).—Non Spach.

Pyracantha crenulata C. Schneider, Ill. Handb. Laubholz. i. 761 (1906); ii. 1004 (1912), in part.—Wilson in Sargent, Pl. Wilson. i. 177 (1912), in part.—Non Roemer.

Pyracantha crenulata var. *yunnanensis*, M. Vilmorin apud Mottet in Rev. Hort. 1913, p. 204, t.—Meunissier in Rev. Hort. 1925, p. 572, fig. 203, pl., fig. 5.

Pyracantha Gibbsii var. *yunnanensis* A. Osborn in Garden, lxxxiii. 138, fig. (March 1919); lxxxvii. 52, fig. (1923).—A. B. Jackson in Gard. Chron. lxxv. 266, fig. 132 A (May 1919).

Pyracantha yunnanensis Chittenden in Gard. Chron. lxx. 325 (1921).—Stapf in Bot. Mag. cli. t. 9099 (1926).—**Synon. nov.**

Pyracantha Gibbsii Rehder in Jour. Arnold Arb. v. 178 (1924); Man. Cult. Trees Shrubs, 362 (1927).—Non A. B. Jackson.

CHINA. Hupeh: Ichang, *Watters*, Herb. Hance, no. 20988 (type) in herb. Brit. Mus.; Hing shan hsien, alt. 3–4000 ft., *E. H. Wilson*, Arnold Arb. Exp. no. 2984, June 1907; Fang, *E. H. Wilson*, Veitch Exped. no. 349, July 1901; Monte Triora, alt. 1950 m., *C. Silvestri*, no. 898, Sept. 1907. Shensi: (ex Stapf). Kansu: near Hui hsien, *F. N. Meyer*, no. 1742, Sept. 26, 1914. Szechuan: valley of Min river, Wen chuan hsien, alt. 4–6000 ft., *E. H. Wilson*, no. 2985, June and Nov. 1908; Kiang tsin district, *C. Y. Hwang*,

no. 233, May 26, 1926; Mt. Omei, *E. H. Wilson*, nos. 4871 and 4871a; Nanchuan hsien, 5-6000 ft., *W. P. Fang*, no. 1356, June 1, 1928. Y u n n a n : Yunnan fu, *C. Schneider*, nos. 44 and 85, Feb. 14 and 19, 1914; north of Yunnan fu, Shi shui tang, *C. Schneider*, no. 297, March 9, 1914; Yunnan fu, alt. 2000-2100 m., *O. Schoch*, no. 20, April 24, 1916.

Among the types which I examined in London last year was *Photinia crenato-serrata* Hance. The type specimen consists of a small flowering branch with obovate, crenate-serrulate leaves. The structure of the flowers which have 5 free styles, as already stated by Hance in the original description, excludes the species from *Photinia* and there can be no doubt that it belongs to *Pyracantha* and is identical with *P. yunnanensis* Chittenden (*P. Gibbsii* Rehd., non A. B. Jackson) which is chiefly characterized by obovate crenate-serrate leaves. This species belongs to a group of very closely related species which, though readily distinguished in their extreme forms, are more or less connected by intermediate forms. These species are *P. crenato-serrata*, *P. atalantioides* (Hance) Stapf (*P. discolor* Rehd.) and *P. crenulata* Roem. and especially its var. *Rogersiana* A. B. Jacks. (*P. Rogersiana* Bean). The geographical and taxonomic relations of these plants are treated in detail by Dr. Stapf (l. c.). I had formerly identified *P. Gibbsii* A. B. Jacks. with the form called originally *P. crenata* var. *yunnanensis*, judging from a figure of a leaf published with the original description and showing a distinct serration. This caused me to redescribe *P. Gibbsii* under the name *P. discolor* which I based on wild specimens with quite or almost entire leaves glaucescent beneath, while *P. Gibbsii* was based on cultivated specimens of which I had seen at that time no material. The difference in the serration is easily explained by the fact that Mr. Jackson's plants were young, vigorously growing, cultivated plants which are apt to produce in a species with a tendency toward serration leaves with a distinct serration, while old mature plants growing under less favorable conditions, as were probably the wild plants which yielded the specimens, are inclined to have entire leaves and at the same time are likely to be more distinctly glaucescent beneath than those of young vigorous plants, which explains why Mr. Jackson did not put stress on the latter character.

Ilex crenata Thbg. f. *bullata*, f. nov.

A typo recedit foliis bullatis i. e. supra convexis et subtus concavis.—Frutex erectus ramis gracilibus erecto-patentibus initio minute puberulis. Folia ovalia vel obovato-ovalia ad oblongo-ovalia, 1.2-2.2 mm. longa et 6-10 mm. lata, apice obtusa et mucron-

ulata, supra lucida. Fructus 5-8 mm. diam., interdum in cymis 3-floris, pedunculis 2-4 mm., pedicellis circiter 3 mm. longis.

Cultivated in the Arnold Arboretum under no. 20069 (plant sent from Japan in 1919 by E. H. Wilson as *I. Mariesii*); specimens in Herb.: A. Rehder, Oct. 4, 1921 (sterile); W. H. Judd, Dec. 23, 1930 (fruiting; type).

This form agrees with typical *I. crenata* Thbg. in its habit forming an upright shrub with spreading branches, but differs in its bullate leaves. It was sent as *I. Mariesii* from Japan in 1919 by E. H. Wilson who probably found it in some Japanese nursery. It was subsequently distributed by the Arnold Arboretum under *I. Mariesii* and later as *I. crenata nummularia*, but it is not *I. crenata* var. *nummularia* Yatabe (*I. crenata* var. *Mariesii* Dallim.) which is a dwarf, very slow growing shrub with crowded suborbicular small leaves. At the Arnold Arboretum var. *bullata* has proved hardier than typical *I. crenata* and even hardier than *I. crenata* var. *microphylla* Maxim. It therefore may be recommended for trial in regions where the typical form has not proved quite hardy.

***Paliurus Hemsleyanus*, nom. nov.**

Paliurus australis Franchet in Nouv. Arch. Mus. Paris, ser. 2., v. 223, (Pl. David. i. 71) (1883).—Non Gaertn.

Paliurus orientalis Hemsley in Kew Bull. Misc. Inform. 1894, p. 387, excl. of the name-bringing synonym and Delavay's specimen cited.—Pritzl in Bot. Jahrb. xxix. 457 (1900).—Schneider, Ill. Handb. Laubholz. ii. 260, fig. 182 c. (1909).—Pampanini in Nuov. Giorn. Bot. Ital. n. ser. xvii. 425 (1910).—Schneider in Sargent, Pl. Wilson. ii. 209 (1914).—Chun, Chin. Econ. Trees, 242 (1922).—Rehder & Wilson in Jour. Arnold Arb. viii. 165 (1927).

CHINA. Eastern Szechuan: South Wushan, A. Henry, no. 7205 (type); same locality E. H. Wilson, Veitch. Exp. no. 634, June 1900; Taning hsien, E. H. Wilson, no. 4630, June 1910; Cheng kou ting, P. Farges. Shensi: "Teiuz sien," G. Giraldis, 1903. Hupeh: Fang hsien, E. H. Wilson, Veitch Exp. without no., June 1901; Ichang, E. H. Wilson, Veitch Exp. no. 105, June and Sept. 1901; without locality, A. Henry, no. 6379, and E. H. Wilson, Veitch Exp. no. 2103, May 1901. Kiangsu: Shien chuan tze, Ching & Tso, no. 454, May 13, 1926; Hai wei, south Tshing, Ching & Tso, no. 596, May 1926; Taiping men, Tso, no. 1116, May 1926. Anhwei: Chuchou, Herb. Univ. Nanking, no. 1701, June 26, 1920; same locality, A. N. Steward, Herb. Univ. Nanking no. 2310, June 14, 1922; Lishan, Chemen, R. C. Ching, no. 3123, Aug. 5, 1925. Kwangtung: C. Ford, no. 325 (ex Hemsley). Kwangsi: without locality, R. C. Ching, no. 7303, Sept. 3, 1928.

Hemsley when describing his *P. orientalis* basing the description chiefly on Henry's no. 7205 considered this number identical with

Paliurus australis var. *orientalis* of Franchet and raised this variety to specific rank conserving the varietal name and citing as the first specimen Delavay's plant from Yunnan, upon which Franchet based his variety. Henry's and Delavay's specimens, however, are not identical, but belong to two geographically clearly separated species with well marked characters. Hemsley's name being based on Franchet's varietal name has to remain with Delavay's specimen and the species represented by Henry's no. 7205 will have to receive a new name for which I here propose *P. Hemsleyanus*.

Paliurus lucidus Carrière in Rev. Hort. 1866, p. 380 referred by Schneider, l. c., doubtfully to this species, probably does not belong here. The name is based on a cultivated plant sent from China by E. Simon and described as a shrub less spiny than *P. aculeatus* and "surtout remarquable par ses feuilles qui sont d'un vert très luisant, comme vernies." The latter character scarcely fits *P. Hemsleyanus*, but applies to *Zizyphus jujuba* Mill. which is common around Peking from where most of the plants came which Simon introduced. No species of *Paliurus* has been found so far in Chihli.

Paliurus orientalis Hemsley in Kew Bull. Misc. Inform. 1894, p. 387, excl. of description and Henry's and Ford's specimen cited.

Paliurus australis var. *orientalis* Franchet, Pl. Delavay, 132 (1889), excl. specimen e Shensi.

Paliurus sinicus Schneider in Sargent, Pl. Wilson, II. 211 (1914); **synon. nov.**

CHINA. Y u n n a n : Ta pin tze near Tali, L. M. Delavay, no. 239, June 1883 (syntype of var. *orientalis*); Mengtze, alt. 4500-4600 ft., A. Henry, no. 9427 (holotype of *P. sinicus*) and 9427 B (paratype).

When in Paris last summer I had an opportunity to examine Franchet's *P. australis* var. *orientalis* and found that Schneider was right in saying (l. c.) that this variety is possibly identical with his *P. sinicus*. It is unfortunate that this makes it necessary to transfer to *P. sinicus* Schneid. Hemsley's combination from the species for which it has been used by all writers until now. The nomenclature of these two species would be much clearer, if we could preserve the name *P. sinicus* for this species, but *P. orientalis* Hemsl. can hardly be classed as a nomen confusum or ambiguum, since with the facts known the application of the name according to our rules of nomenclature is perfectly clear.

Tilia chinensis Maxim. f. *investita* (V. Engl.), comb. nov.

Tilia Baroniana var. *investita* V. Engler, Monog. Tilia, 132 (1909).

A typo reedit foliis subtus sparse vel sparsissime piloso-stellatis cinereo-viridibus, petiolis ut ramuli leviter pruinosi glabris.

CHINA. *Shensi*: Huan-tou-san, *G. Giraldi*, no. 7142 (holotype).

This form which has the leaves sparingly stellate-pilose beneath and not glabrous as described by V. Engler is connected with the type by the form described as *T. Baroniana* Diels which differs from the type chiefly in the glabrous petioles and branchlets and the less densely pubescent under side of the leaves which are often somewhat more distinctly and sharply serrate. The form described as *T. Baroniana* seems to be the most widely distributed, while typical *T. chinensis* with pubescent branchlets and petioles is a rarer extreme form and looks very distinct from the other extreme represented by f. *investita* which also seems rare, but they are closely connected by intermediate forms which may be distinguished as f. **Baroniana** (Diels.), f. nova. Engler cites under his var. *investita* as a synonym *T. cordata* Diels in Bot. Jahrb. xxxix. 468 (1901) not Miller, but enumerates under *T. Baroniana* Giraldi's no. 1313, the only specimen quoted by Diels for *T. cordata*. As I have not seen Giraldi's no. 1313, I am not able to say whether *T. cordata* Diels should be referred to *T. Baroniana* as a synonym or whether Giraldi's no. 1313 should be quoted under var. *investita*.

Osmanthus fragrans Loureiro, Fl. Cochinch. i. 29 (1790).—De Candolle, Prodr. viii. 291 (1844).—Rehder in Sargent, Pl. Wilson. ii. 609 (1916).

Olea Thunbergii Thunberg, Fl. Jap. 18, t. 2 (1784).

Olea acuminata Wallich, Cat. no. 2809 (1828), nom. nudum.—De Candolle, Prodr. 291 (1844).

Olea ovalis Miquel in Jour. Bot. Neerl. i. 111 (1861).

Pittosporum yunnanense Franchet in Bull. Soc. Bot. France xxxiii. 413 (1886); **synon. nov.**

When in Paris last summer I examined among other types of Franchet's species also his *Pittosporum yunnanense* based on Delavay's no. 780, from Yunnan and found that it is not a *Pittosporum* at all, but *Osmanthus fragrans* Lour. Franchet overlooked entirely the opposite leaves and his description of the fruit as "bivalvis" was apparently based on a few fruits in which the exocarp had split at the apex through pressure. The specimen had apparently been examined critically before, for there was a note on a little pocket containing some fruits stating "n'est pas un Pittosporum."

Clerodendron cyrtophyllum Turczaninow in Bull. Soc. Nat. Moscou, xxxvi. pt. iii. 222 (1863).—Rehder in Sargent, Pl. Wilson. iii. 377 (1916).

Clerodendron amplius Hance in Ann. Sci. Nat. ser. 5, v. 233 (1866).—Franchet in Nouv. Arch. Mus. Paris, ser. 2, vi. 111 (Pl. David. i. 231) (1883).

Clerodendron formosanum Maximowicz in Bull. Acad. Sci. St. Petersb. xxxi. 85 (1886); in Mel. Biol. xii. 519 (1886).

Cordia venosa Hemsley in Jour. Linn. Soc. Bot. xxvi. 143 (1890); **synon. nov.**

On examination of the type of *Cordia venosa* Hemsl. at Kew I found that this species is identical with *Clerodendron cyrtophyllum* Turcz. The type specimen was collected by E. Faber in 1887 on the Ningpo Mountains and distributed as Faber, no. 183. The specimen consists of a small branch with two rather sparingly branched inflorescences only 6–10 cm. in diameter bearing a small number of mature fruits with enlarged calyces and young calyces without corollas. On account of its small inflorescences the specimen looks quite unlike the usual specimens with inflorescences 15–30 cm. in diameter, but on closer examination the specimen agrees in all its parts perfectly with *C. cyrtophyllum*. Flowering material of this species from the same locality collected by E. Faber in 1888 under no. 645 is represented in this herbarium.

Viburnum setigerum Hance in Jour. Bot. xx. 261 (1882).—Hemsley in Jour. Linn. Soc. xxiii. 356 (1888).—Rehder in Sargent, Trees & Shrubs, II. 112 (1908).

Viburnum phlebotrichum Hemsley in Jour. Linn. Soc. xxiii. 354 (1888).—Graebner in Bot. Jahrb. xxix. 589 (1901).—Mottet in Rev. Hort. 1919, p. 264, tab. col. (1919).—Non Siebold & Zuccarini.

Viburnum theiferum Rehder in Sargent, Trees & Shrubs, II. 45, t. 121 (1907), 114 (1908); in Fedde Rep. Spec. Nov. ix. 183 (1911); in Sargent, Pl. Wilson, I. 112 (1911); Man. Cult. Trees & Shrubs, 806 (1927); in Jour. Arnold Arb. viii. 197 (1927).—Schneider, Ill. Handb. Lauleholz. II. 645, fig. 413 e-f. (1911).—Bean, Trees Shrubs Brit. Isles, II. 657 (1914); ed. 4, p. 657 (1925).—McFarland in Gard. Mag. xxxiv. 42, fig. (1921).—**Synon. nov.**

Viburnum Bodinieri Léveillé in Fedde, Rep. Spec. Nov. ix. 442 (1911); Fl. Kouy-Tchéou, 65 (1914); **synon. nov.**

CHINA. Eastern Szechuan: "in monte Ko-lo-shan, ab aestivo occasu oppidi Chun-king, alt. 2000 ped.," W. Mesny (Herb. Hance no. 21739), July 1880 (type in Herb. Brit. Mus.); South Wushan, A. Henry, no. 5586 (paratype of *V. theiferum*); Nanchuan hsien, W. T. Fang, no. 1107, May 27, 1928; Kikiang hsien, W. P. Fang, no. 1330, June 11, 1928; without precise locality, W. P. Fang, no. 433. Kweichow: "Kouy-Yang, bois de Kin-Lin-Chan," E. Bodinier, no. 2193, April 14, 1898 (syntype of *V. Bodinieri*, in Herb. Edinb.; merotype in Herb. Arnold Arb.); Pin fa, J. Cavalerie, no. 1285, May 1903 (syntype of *V. Bodinieri* in Herb. Edinb.). Hupeh: Kui, E. H. Wilson, Veitch Exped. no. 579, April and Autumn 1901 (holotype of *V. theiferum*); Chang yang, E. H. Wilson, Veitch Exped. no. 644 (paratype of *V. theiferum*); Chang lo hsien, E. H. Wilson, no. 236, June & Sept. 1907; Ichang, E. H. Wilson, no.

218, 218 bis, May & Sept. 1907; Giu gia swan, *W. Y. Chun*, no. 3814, Aug. 9, 1922; He ya tze, *W. Y. Chun*, no. 3983, Aug. 20, 1922. H u n a n : Chang cha, Yolu shan, *Handel-Mazzetti*, no. 11615, April 4, 13, 1918. K i a n g s i : Kuling, *E. H. Wilson*, no. 1711, July 31, 1907; Mt. Yun touling, *Wang Te Hui*, Pl. Sin. Cur. *Handel-Mazzetti* no. 269, April 1921; An fu wu kung shan, *H. H. Hu*, no. 708, 122, April 21 and 22, 1921; Yuŋ shing hsien, Ih shan, *H. H. Hu*, no. 802, May 5, 1921. A n h w e i : Kimen, *N. K. Ip*, no. 36 (Herb. Univ. Nanking, no. 5249), April 23, 1924; also no. 5266, April 24, 1924; same locality, *R. C. Ching*, no. 2644 (University Nanking no. 7572 and 2780), May 1, and June 27, 1925. C h e k i a n g : Dong si, near Han chow, *F. N. Meyer*, no. 446, in 1907; East Tien mu, *H. H. Hu*, no. 1619, June 20, 1927; Yu tsien hsien, *Y. L. Keng*, no. 518, June 26, 1927; Sui an hsien, *Y. L. Keng*, no. 780, July 14, 1927; without precise locality, *R. C. Ching*, no. 4784.

When in London last summer I examined the type of *Viburnum setigerum* Hance which never had been identified with any of the more recently collected *Viburnums* and found that it is identical with my *V. theiferum*. Also *V. Bodinieri* Léveillé which I had an opportunity to see two years ago in Edinburgh belongs here.

The species was first introduced into cultivation by E. H. Wilson in 1901 from Kui, Hupeh, and distributed by the Veitchian Nurseries. Seeds were again sent in 1907 by him from Chang lo hsien to the Arnold Arboretum. Among the plants raised from the seed of his later introduction one was found which bore fruits of a bright orange color and may be distinguished as a color form under the following name:

Viburnum setigerum f. *aurantiacum*, f. nov.

A typo recedit fructibus aurantiacis.

Cultivated at the Arnold Arboretum under no. 20189 (raised from seed of Wilson's no. 236); type specimen in Herb. Arnold Arboretum, *A. Rehder*, Oct. 13, 1926.

This handsome form differing from the type with scarlet fruit in its bright orange-red fruits was raised from seed collected by E. H. Wilson in Chang-lo hsien, Hupeh, under no. 236; from the same number also the typical red-fruited form was raised.

(To be continued)